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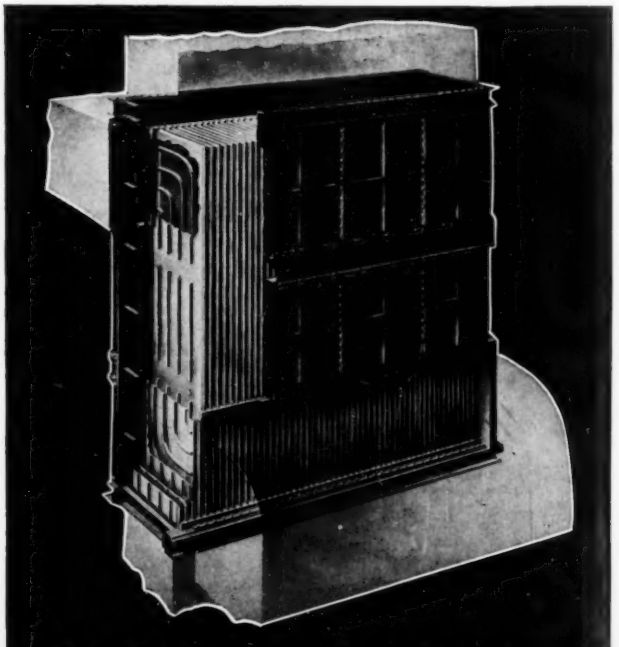

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The Monthly Journal Published by

The American Society of Mechanical Engineers

Publication Office, 20th and Northampton Streets, Easton, Pa. Editorial and Advertising Departments at the Headquarters of the Society, 29 West Thirty-Ninth Street, New York

Volume 51 | October, 1929, Section One | Number 10

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Entered as second-class matter at the Post Office at Easton, Pa., under the Act of March 3, 1879.
Acceptance for mailing at special rate of postage provided for in Section 1103, Act of October 3, 1917, authorized on January 17, 1921.

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* * *

This month's cover, depicting sea gulls in various attitudes of flight, is used in connection with the article published in this issue by Prof. Maurice Boel on "Studies in Natural Flight."

MECHANICAL ENGINEERING

Volume 51 October, 1929 No. 10

Trends in Power-Plant Development in the United States and Europe

By C. F. HIRSHFELD,[1] DETROIT, MICH.

IN STUDYING any contemporaneous phase of human activity it is well to start with a fairly intimate knowledge of the history of events leading up to the situation under study. The consideration of developments in the field of power production in this country and in Europe cannot be treated properly without such a survey of that which preceded. For this reason I am going to show you first some graphs which will serve to visualize the direction and extent of progress over a rather lengthy period.

The Rise in Steam Pressures Since 1900

The curve of Fig. 1 shows the way in which the steam pressure used in representative central stations has risen since 1900, practically three decades ago. The data apply particularly to conditions in the United States. The shaded area illustrates the range of good practice.

You will note that we have now arrived at three radically different schools of practice, what we may call the 400-lb. school, the 600-lb. school, and the 1200-lb. school. The lowest of these pressures, which in fact varies between 400 and 500 lb. at the boiler drum, is chosen as the highest pressure that can be used safely without reheating at the highest initial steam temperature that it is desired to use and consistent with cost of boiler. The two higher pressures both involve the use of reheat at the present time and are otherwise useless for condensing operation because of the large quantities of water that would be formed during expansion.

The present tendency is to choose the 1200- to 1400-lb. range in preference to the 600-lb. pressure. This appears to be the choice dictated by economic considerations. While the wall thickness required with 1200-lb. internal pressure would be higher than that required with 600 lb. and the same diameters, the volumes at 1200 lb. are so much smaller than at 600 that the actual weight of material to be purchased and space to be provided work out to the advantage of the higher pressure.

In Europe they have not stopped at 1400 lb. but have gone higher with special types of plant to which I shall refer later.

Temperature Rise More Gradual Than That of Pressure

The history of steam temperatures is shown in Fig. 2, with the hatched area representing the range of good practice as before. You will note that while we have gradually raised the temperature, as we have the pressure, there is no such sudden rise of temperature in recent years as has occurred in the case of pressure. At present a total temperature of 750 deg. fahr. is about the limit in this country, although some engineers are speculating on the possibility of raising this value by 50 to 100 deg. In Europe there are several experimental and semi-commercial plants operating at temperatures well above those that we now regard as the limit in this country. The temperatures in some of these plants run up to about 900 to 950 deg. fahr. as a maximum, and a plant known as Langerbrugge, in Belgium, is actually operating commercially with a steam temperature in the neighborhood of 800 to 825 deg. fahr.

The maximum temperature is dictated primarily by what one regards as the safe limit for available metals. We in the United States have assumed until quite recently that 750 deg. fahr. is as high as it is safe to go with tubes made of low-carbon steel. We are now beginning to believe it possible to raise this temperature by 50 to possibly 100 deg. fahr. with the same tube material. In Europe they have been much more optimistic, and this fact illustrates a difference in mental attitude. It is not that Europe has better metal than we have, that the European engineers know more about the properties of metals than we do, nor that metal behaves any differently in Europe than it does here. The explanation lies in a radically different conception of the relative importance of certain things.

We place great weight upon the degree of availability of our equipment. Satisfactory performance with us means a very high degree of availability, say, between 85 and 95 per cent on an annual basis. We also recognize our inability to control conditions perfectly at all times and our inability, in general, to obtain men who will be forever mentally alert and watching every detail of control. As a result we allow ourselves a very large factor of safety. There is no doubt but that one can build a superheater of low-carbon steel which will give satisfactory operation at temperatures in the neighborhood of 900 deg. fahr. at least. But we have preferred to have a factor of safety of about 150 to 200 deg. fahr.

In Europe, and particularly on the Continent, they attack the matter from a different angle. They place more stress upon the available thermal efficiency and less upon troubles. They place more faith in their ability to control as predicated during design. They place more weight on laboratory showings because of their high regard for scientific laboratory work and because of a smaller practical experience than we bring to bear. As a result you will find that continental European engineers are apt to provide much smaller factors of safety than we are.

The increases of steam pressure and temperature just outlined have resulted primarily from efforts to obtain higher thermal efficiencies. Contemporaneously we have been following other lines of progress which were directed toward reduction of invested capital and of the necessary labor per unit of capacity and per unit of output, respectively.

[1] Chief, Research Department, Detroit Edison Co. Mem. A.S.M.E.

A lecture delivered at the S.P.E.E. Summer School for Mechanical Engineering Teachers, Purdue University, June 27 to July 18, 1929.

INCREASE IN OUTPUT PER BOILER UNIT

One of the best examples of this second type of progress is illustrated in Fig. 3, which shows the increase in total heating surface of single boiler units. Starting in 1900 with units of the general magnitude of 4000 sq. ft., we have arrived at common practice about eight times as large and in exceptional cases, more than fourteen times as large. However, heating surface is a poor measure of the advance since it is really the output per boiler unit that counts. This is shown in Fig. 4. Starting at 1900 with 10,000 to 20,000 lb. steam per hour we have now reached over 300,000 lb. in representative practice and as high as 800,000 lb. in exceptional cases.

The number of men required per boiler unit has remained substantially constant during this tremendous change, so that the pounds of steam produced per man-hour has increased tremendously. Incidentally, the thermal efficiency of the boiler room has risen in this period from values between 65 and 75 per cent to values between 85 and 90 per cent, so that there has been a marked change in this respect also. Part of this is traceable to the use of larger units, but a much greater part is traceable to improved combustion and heat-absorbing equipment.

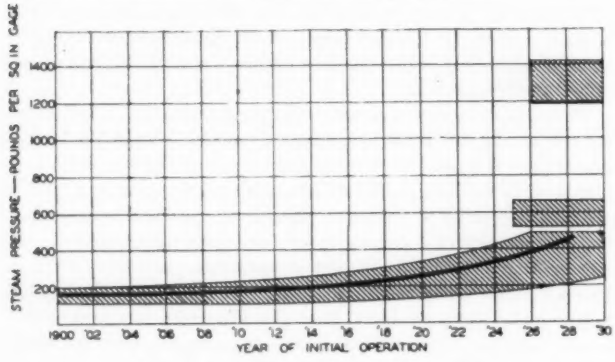

FIG. 1 INCREASE IN STEAM PRESSURES
(Shaded areas indicate approximate limits of central-station practice.)

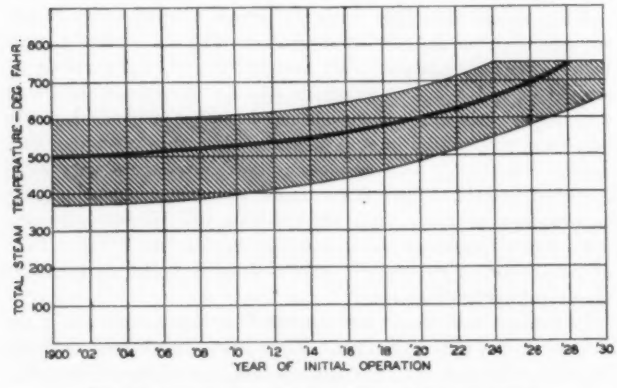

FIG. 2 INCREASE IN TOTAL STEAM TEMPERATURE
(Shaded area indicates approximate limits of central-station practice.)

There is a very appreciable capital saving through the use of large boiler units. It would require a long consideration of details to show how this comes about. It results from economy of floor and building space, economy of piping, fittings, and parts, economy in the use of furnace walls, and things of such sort as well as from—or in some cases in spite of—changes in the actual cost of the boiling vessel.

GROWTH OF TURBINE CAPACITY

The same sort of thing has happened with respect to the steam turbine, as shown in Fig. 5. Starting at 1900 with reciprocating steam engines at their zenith and the turbine a matter of speculation, we find multi-cylinder units of over 200,000 kw. capacity installed in 1929. The single-barrel unit is built in sizes over 100,000 kw. capacity at present. The same sort of results obtained through the use of larger boiler units have been obtained in the turbine room through the use of larger turbine units and associated equipment. As in the case of the boilers there has been a remarkable increase in turbine-room thermal efficiency, but here also increase of size has been responsible for only a small part of this improvement.

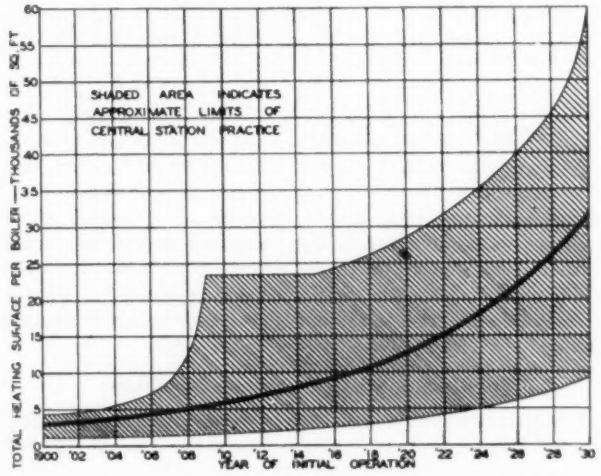

FIG. 3 INCREASE IN PHYSICAL SIZE OF BOILER UNITS

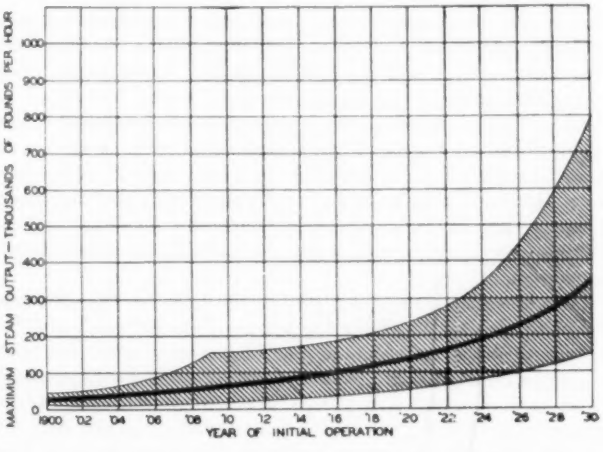

FIG. 4 INCREASE IN STEAMING CAPACITIES OF BOILER UNITS
(Shaded area indicates approximate limits of central station practice.)

REDUCTION OF HEAT REQUIREMENT PER UNIT OUTPUT

As a sort of summary of the development of thermal efficiency, Fig. 6 is presented. It shows the way in which the thermal performance per kilowatt-hour send-out has increased during a comparatively short period of time. It is interesting to note that the latest developments of the mercury-vapor equipment indicate the possibility of reaching at least as low as 10,000 B.t.u. per kw-hr., and probably lower. The attainment of 10,000 B.t.u. by 1930 would represent a decrease in two decades to about one-third the heat requirement at the beginning of the period. When it is realized that this has been done with proper regard to preserving the necessary balance with respect to all other factors concerned, it becomes obvious that it is a truly notable achievement. But,

it does not stand unique; achievements of similar magnitude have been made in many other fields of human endeavor. And it is this grand accumulation of advances that has so quickly and completely changed the world we live in and the conditions under which we live.

HEAT CONSUMPTION OF TURBINES

We may now study in greater detail the significance of higher steam pressure in a thermal sense. For this purpose I shall use a diagram prepared by Dr. Münzinger[2] of the A.E.G. which is reproduced in Fig. 7. The upper three curves show the theoretical heat consumption of the turbine at different initial pressures and three initial temperatures when operating without bleeding, that is, without regenerative feedwater heating. The lower group of three curves shows similar values with regenerative feed heating in two stages.

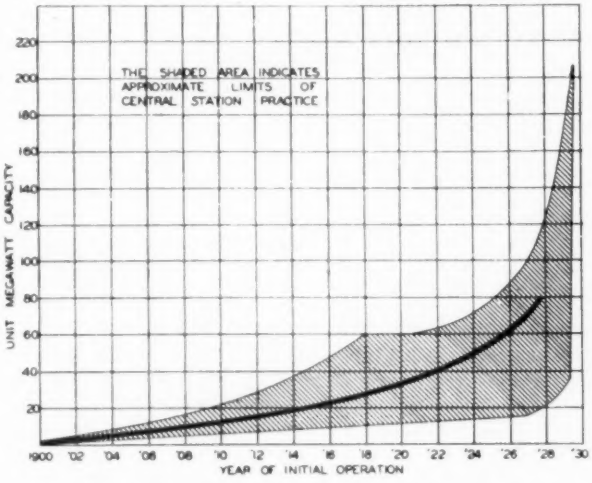
THE SHADED AREA INDICATES APPROXIMATE LIMITS OF CENTRAL STATION PRACTICE
UNIT MEGAWATT CAPACITY
YEAR OF INITIAL OPERATION

FIG. 5 INCREASE IN MAIN UNIT TURBINE SIZES

It is to be noted first that the mere increase of pressure in the higher ranges is not particularly effective. Thus points A_1 and A_2 indicate a gain of 3.4 per cent for an increase of 200 lb. from 400 to 600, while points B_1 and B_2 indicate a gain of only 0.7 per cent for a similar numerical increase of pressure starting at 2000 lb. per sq. in.

It is also important to note that as the pressure is increased at any given initial temperature the quality of the exhaust decreases. We do not yet know how far we may go in this direction, but present practice in the United States leans rather strongly toward limiting the moisture in the exhaust to some value not greatly in excess of 10 per cent. High initial pressure alone works against the attainment of high commercial efficiency because of the increasing losses resulting from excessive moisture in the low-pressure stages of the turbine and because of the excessive wear to be expected. High initial temperature works in exactly the opposite direction.

The most striking thing shown by this chart is the remarkable gain that may be achieved by regenerative feedwater heating. Thus if we consider the points indicated by circles on the 8200-B.t.u. line, we find that the performance indicated at 400 lb. and 1000 deg. fahr. and at 550 lb. and 800 deg. fahr., both with *two-stage feedwater heating*, is the same as that obtainable at 900 lb. at 1000 deg. fahr. and at 1400 lb. and 800 deg. fahr. without bleeding.

In addition to this thermal advantage, bleeding for feedwater heating decreases the necessary size of the low-pressure end of the turbine, thus raising the limit of size which may be constructed with single flow, and it also decreases very materially the size of condenser and the amount of circulating water that must be pumped.

THERMAL GAINS OBTAINABLE BY REGENERATIVE FEED HEATING

In Fig. 8 are shown the thermal gains obtainable by different degrees of regenerative heating in various numbers of steps for initial conditions of 850 lb. at 800 deg. fahr. and exhausting to vacuum 7, all as developed by Dr. Münzinger. It is interesting to note that one can go too far in raising the temperature in this way, and it must be remembered that this diagram does not take into account the boiler-room performance. The curves indicate that little gain is shown with more than three bleeding stages. When pressure drops and necessary temperature heads and investments are brought into the picture it is generally found that the use of two or at most three bleeder stages represents the best

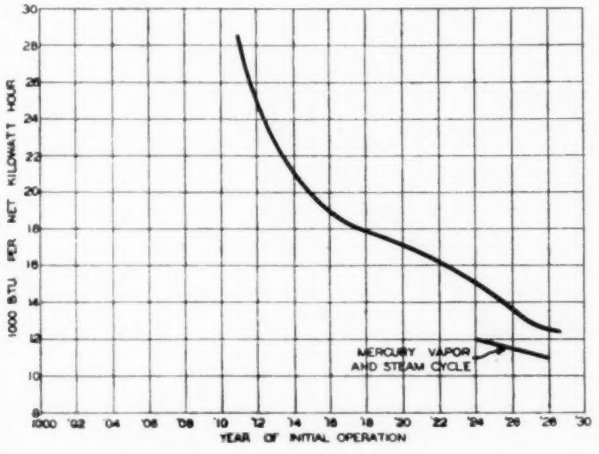

FIG. 6 THERMAL ECONOMY OF PLANTS OPERATING ON 50–60 PER CENT ANNUAL LOAD FACTOR

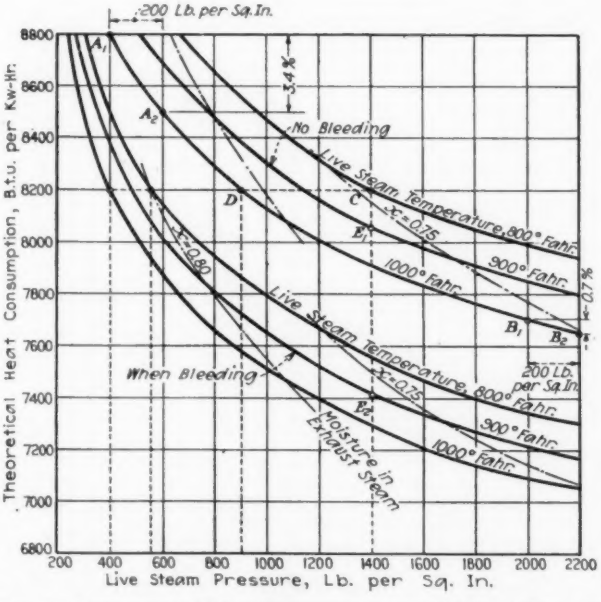

FIG. 7 THEORETICAL HEAT CONSUMPTION PER KW-HR. WITH AND WITHOUT BLEEDING, AT DIFFERENT LINE STEAM PRESSURES AND TEMPERATURES

[2] "Fuel Control in Electric Power Stations," a paper delivered before the Institute of Fuel on Nov. 22, 1928. See the *Journal of the Institute of Fuel*, vol. 2, no. 5, October, 1928, p. 55.

practice, although it must be remembered that the number ought to increase as the initial pressure increases.

With the maximum steam temperature now regarded as safe it is not found desirable to exceed a certain steam pressure without resorting to reheating at some point during the expansion. With a limiting steam temperature of 750 deg. fahr. the limiting pressure is in the neighborhood of 475 to 500 lb. Reheating has

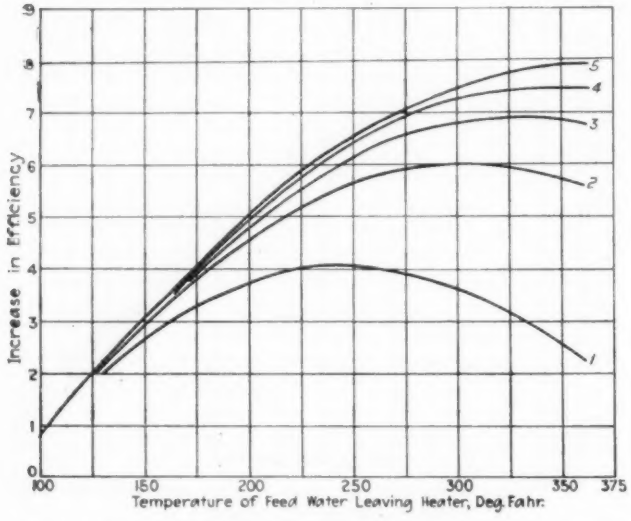

FIG. 8 INCREASE IN EFFICIENCY AT VARIOUS TEMPERATURES OF THE HEATED FEEDWATER AND WITH VARYING NUMBER OF EXTRACTION POINTS

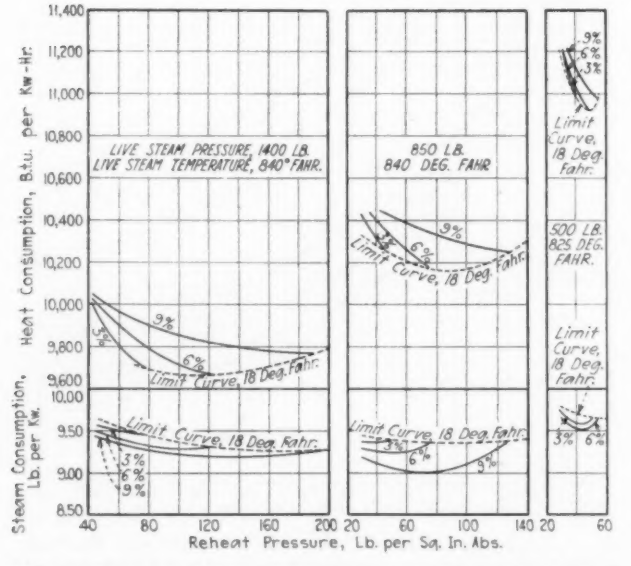

FIG. 9 HEAT AND STEAM CONSUMPTION AT DIFFERENT REHEAT PRESSURES AND DIFFERENT MOISTURE CONTENTS OF THE EXHAUST OF THE TURBINE

therefore been resorted to in both this country and Europe as a means of utilizing the higher steam pressures. It is not commonly realized that the thermal gain obtainable by going to these higher pressures lies very largely in the greater range of regenerative feedwater heating and not in the reheating. The latter ought therefore to be regarded more as a means of making the former possible than as of primary importance of itself.

There are two schools of thought regarding the method to be used for reheating. One advocates return of the steam to gas-heated reheaters in the boiler room, and the other the use of steam-heated reheaters in the turbine room. At present it appears that the first method works out well with 1200-lb. equipment, and the second method with 600-lb. equipment. This is possibly explainable by the smaller volume of the higher-pressure steam and the smaller parts that result.

It should also be noted that there is still a lot of theoretical work to be done in the field of reheating. There are so many variables concerned, so many possibilities, and such wide differences in investment required, that it will probably take several years more to completely analyze the problem from the theoretical and semi-commercial angles.

THERMAL CONSUMPTION OF TURBINES UNDER CERTAIN ASSUMED CONDITIONS

One interesting study, again due to Dr. Münzinger, is shown in Fig. 9. He has developed the thermal consumption of the turbine

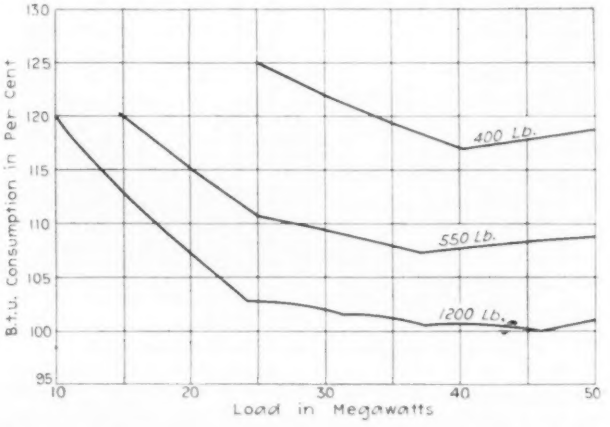

FIG. 10 THEORETICAL ECONOMIES ATTAINED AT VARIOUS STEAM PRESSURES WITH A 50,000-KW. TURBINE

under certain assumed conditions. The principal conditions are: several temperatures and pressures as shown on the diagram, live-steam reheating, three-stage feedwater heating, an 18-deg. fahr. difference between reheating and reheated steam, and several different moisture contents in the exhaust. It is of interest to note the very large number of variables concerned and the wide differences in the results.

The results of a somewhat similar study as applied in a real case are shown in Fig. 10. These graphs were prepared during the preliminary design of the Holland Station[3] and show the theoretical economies obtainable with what was assumed to be the commercially best arrangement in each case. I show you this set of graphs to point out two things. First, the range between best points at 1200 lb. and at 400 lb. is only of the order of 16 to 17 per cent in this theoretical study. Under actual operating conditions the performance of the 1200-lb. plant is probably only about 10 per cent better than that of its 400-lb. competitor. Second, it is necessary in most real cases to study not only conditions at maximum output or conditions at the best point, but also conditions throughout the entire operating range. You will note that the high-pressure graph is much more nearly flat over a very wide range than is either of the others. I am not prepared to say that this is an inherent characteristic, suffice it that the calculations came out in this way in this case.

In Fig. 11 are shown the results of another study made by Dr. Münzinger. Since this diagram gives total costs it was necessary for Dr. Münzinger to determine the required investments for the

[3] *Power Plant Engineering*, March 1, 1929.

different conditions studied. The plant is conservatively designed, that is, allowances for spares, operating facilities, and such are generous. It contains approximately 360,000 kw. installed capacity. The investment is converted to terms of plants having the same net output. If the investment in a 500-lb. plant be considered 100 per cent, then his figures show 104.3 per cent for the investment in an 850-lb. plant and 109.9 per cent for a 1400-lb. plant. In so far as one can judge from the rather meager data available, the ratios would not be very different in the United States at present, although the cost of 1400-lb. equipment appears to be dropping as experience is accumulated.

The scales used in Fig. 11 are such that if the vertical scale is divided by the lower horizontal scale, the result is the cost of each kilowatt-hour of send-out.

It is interesting to note the comparatively wide range in which the three widely different pressures do not give materially different results. It is this fact that has made it so difficult to determine by calculation in advance just what pressure is best under a given set of circumstances.

From what I have said thus far it is obvious that there is a marked trend toward higher steam pressures, and, to a lesser extent, toward higher steam temperatures. I think it well to say at this point that there is still a marked difference of opinion among engineers regarding the proper pressure for different conditions. It appears to be definitely proved that the 1200- to 1400-lb. plant as now built in the United States is a paying proposition with a reasonably high fuel price, say, $4.50 to $5.00 per ton of 13,000-B.t.u. coal, and a reasonably high capacity factor, approximating "base-load conditions." At least some of the executives and engineers who have had experience with such plants claim that it is not limited to base-load conditions.

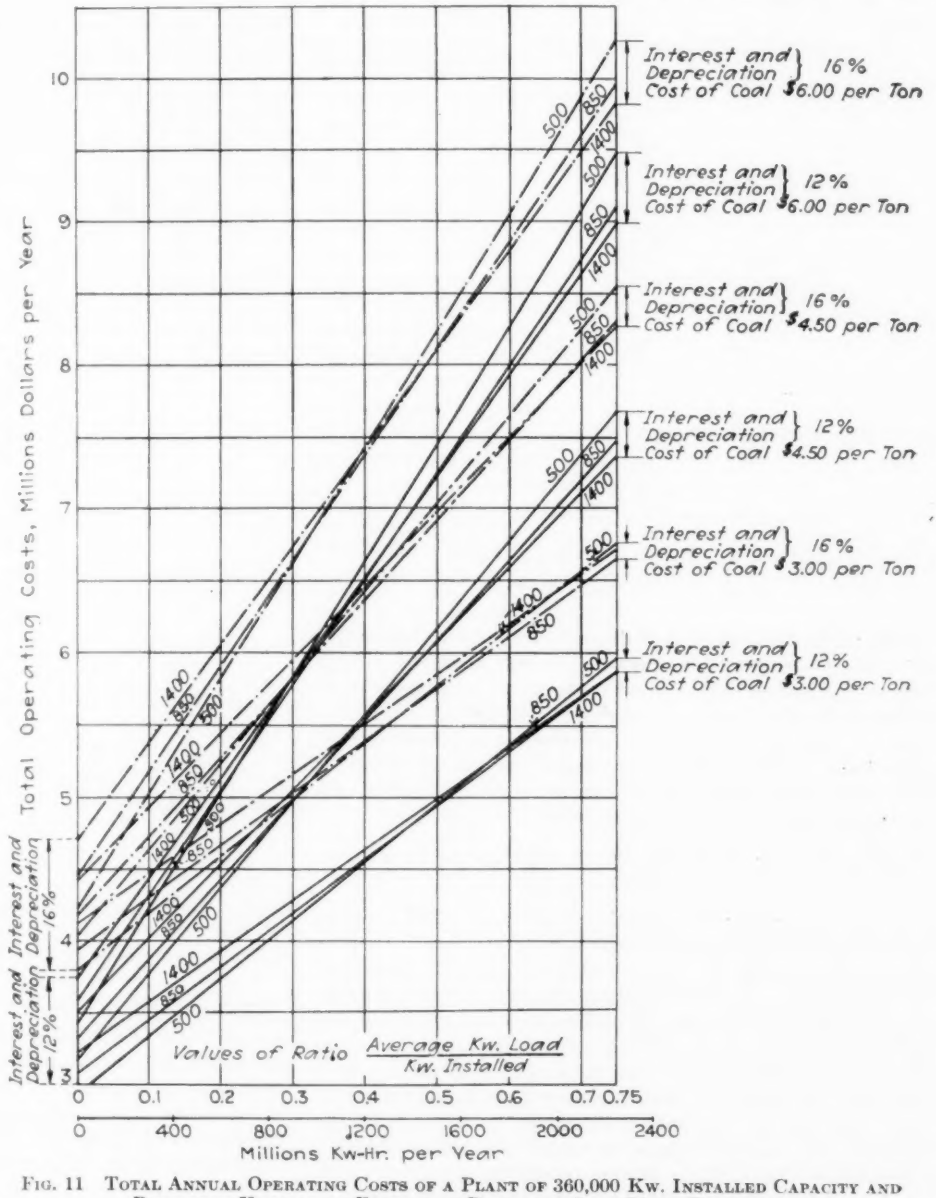
Interest and Depreciation 16% Cost of Coal $6.00 per Ton
Interest and Depreciation 12% Cost of Coal $6.00 per Ton
Interest and Depreciation 16% Cost of Coal $4.50 per Ton
Interest and Depreciation 12% Cost of Coal $4.50 per Ton
Interest and Depreciation 16% Cost of Coal $3.00 per Ton
Interest and Depreciation 12% Cost of Coal $3.00 per Ton
Total Operating Costs, Millions Dollars per Year
Interest and Depreciation 16%
Interest and Depreciation 12%
Values of Ratio Average Kw. Load / Kw. Installed
Millions Kw-Hr. per Year
500
850
1400

FIG. 11 TOTAL ANNUAL OPERATING COSTS OF A PLANT OF 360,000 KW. INSTALLED CAPACITY AND DIFFERENT UTILIZATION FACTORS AT DIFFERENT LINE STEAM PRESSURES

CHANGES BROUGHT ABOUT BY DEVELOPMENT OF HIGH-PRESSURE EQUIPMENT

The development of high-pressure equipment has brought about many changes throughout the plant which are generally overlooked until one comes to the making of a complete study. Reference has already been made to the way in which condenser size is reduced by regenerative feedwater heating. It is obvious that the reduction will be greater the higher the initial steam pressure, with all other things equal. Changes in the boiler room are just as significant, possibly more so.

The rapid decrease in the numerical value of the latent heat of evaporation with increasing pressure is well known. The drop in the range from 400 lb. to 1200 lb. is of the order of 20 per cent. In addition, the high-pressure steam plant is thermally more efficient than the low-pressure steam plant, so that less heat has to be supplied the turbine room per unit of output. Further, the saturation temperature increases as the steam pressure increases, and the attainment of maximum economy in the turbine room dictates heating the condensate with bled steam up to values which increase markedly with increase of pressure.

These things all react in the boiler room in peculiar and definite ways. The principal effects are:

a The evaporating surface is reduced as the pressure increases, due to lower latent heat and less heat to be produced.

b The products of combustion leave the evaporating surface at higher temperatures, the higher the pressure.

c The temperature of water entering the economizer increases with increasing steam pressure, and an economizer therefore becomes more and more unable to reduce the flue gases to the low temperature desired for high economy.

d An air preheater becomes more and more necessary as the pressure increases in order to span the range between economizer exit gas temperature and the desired low temperature of stack gases.

No one can tell just how this combination of factors will result in any given case. But, in general, the boiler surface decreases markedly as the pressure rises and the total extent of heat-absorbing surface increases. The latter effect appears to occur in such a way that a peak value is reached at some elevated pressure and beyond that value the total surface again decreases. This is as yet highly speculative, however.

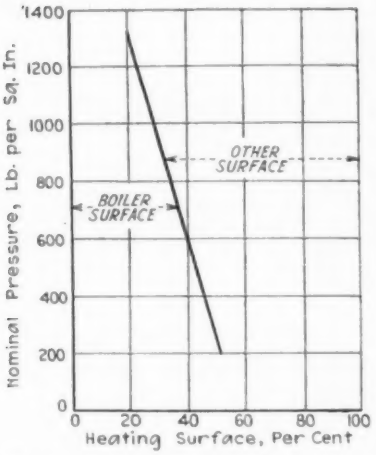

FIG. 12 BOILER HEATING SURFACE AS PERCENTAGE OF TOTAL HEATING SURFACE

CHARGE OF SURFACE DISTRIBUTION WITH PRESSURE

In Fig. 12 I have endeavored to give an idea of the way in which the distribution of surface changes with pressure. It is assumed that both economizer and air preheater are used and that the boiler-room efficiency sought is in the neighborhood of 90 per cent. The line drawn in the figure represents an average of the values found in actual cases. The range at any pressure except the highest is very wide, so the line should be interpreted more as indicating a trend than as representing absolute values.

PRESENT TYPE OF HIGH-PRESSURE PLANT PROBABLY A TRANSITION TYPE

I have felt for some time that the present type of high-pressure plant is probably nothing more than a transition stage. To me it seems far more logical to do one of two things: The first is to develop materials capable of withstanding much higher temperatures and then to build up to the highest pressure which is usable with such temperatures without reheating. The other is to abandon our present attempt to adhere to more or less standardized types of equipment, to develop new types capable of use at very high pressures such as 2000 lb. or higher, and to obtain the maximum advantage of decrease in overall size, and of range for regenerative feed heating. The first possibility seemed to me to be the most promising at present, in that it appeared capable of commercial development with the minimum changes from standard equipment. For this reason I have advocated advance along such lines, and the company with which I am connected is now engaged in a rather extensive and expensive high-temperature experiment. We shall shortly have in operation a 10,000-kw. turbine designed for an initial steam temperature of 1000 deg. fahr., and we hope to have available at that time a superheater capable of delivering steam at such a temperature. As a matter of fact, we have had in experimental operation for some time a superheater delivering steam at 1000 deg. fahr. or higher and we have not yet discovered any insurmountable obstacles.

If we are successful in the use of such temperatures as 1000 to 1100 deg. fahr. it will be logical to step up the steam pressure to some such value as 800 to 900 lb. per sq. in.—we do not yet know just what. After that the next step will probably be a further increase of temperature, followed by a corresponding increase of pressure.

Several European engineers have followed more closely the second possibility outlined above. They have struck out boldly into entirely new principles, arrangements, and designs. This may be attributed partly to the type of mind and the characteristic method of attack, and partly to differences in the conditions there and here.

They all start with certain assumed upper temperature limits, as dictated by the metal. They all start with the idea that the conventional type of boiler is not adapted to very high pressures for one reason or another. From there on they travel their separate and devious ways.

In the early days of these developments I doubted the need of any such contraptions. Recently, however, I have had occasion to change my mind. It is becoming obvious that at a pressure of 1400 lb. the more or less conventional American type of design

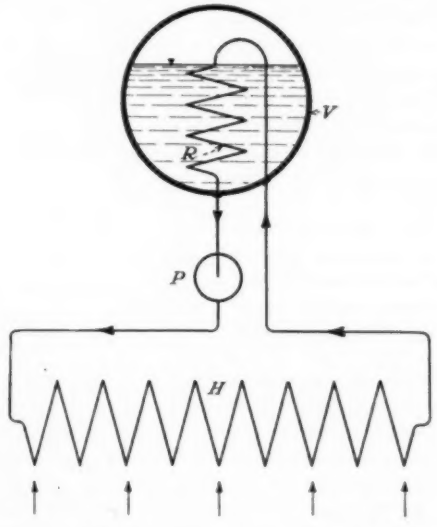

FIG. 13 INDIRECT STEAM GENERATION BY MEANS OF MECHANICALLY CIRCULATED HEAT CARRIER
(*H*—Heated pipe coil; *P*—Circulating pump; *R*—Vaporizing coil; *V*—Vaporizer.)

begins to approach a limit. Anything short of perfectly nonscaling water is certain to lead to trouble very quickly. Any excessively intense flame impingement upon furnace-wall tubes must have the same result. There are also other features, such as very delicate balances in circulation, which indicate approach toward a practical limit not very far above 1400 lb. pressure with conventional types of equipment.

Of course the mercury-vapor plant developed in this country is in a sense a solution of the high-pressure-steam problem. But it is a solution which is effective through the elimination of high steam pressure by the addition of many complicating features. It attains the desired efficiency but at a cost in complication and what now appears to be a rather large increase of investment.

EARLY ATTEMPTS TO OVERCOME DIFFICULTIES OF HIGH-PRESSURE STEAM GENERATION

One of the early attempts to overcome some of the difficulties of steam generation, and particularly high-pressure steam genera-

tion, is shown diagrammatically in Fig. 13. A heat carrier is circulated in a closed system by means of a circulating pump. Various substances from mercury down have been suggested as the heat carrier, but none has yet given great promise. Each is handicapped in one way or another. In addition, scale-forming water tends to encrust the outer surface of the coil in the drum which forms the steam generator, thus decreasing the effectiveness of the heating surface.

The device shown diagrammatically in Fig. 14 has already achieved some success in Europe, particularly for locomotive work. The heat carrier is distilled water, so that the surfaces subjected to furnace heat and furnace gases are maintained absolutely clean on the water side. Any grade of water may be used in the boiler proper, that is, in the large drum shown on the diagram, but if it carries incrusting solids the heat transfer coils R are rapidly reduced in effectiveness. Moreover the circulation of the heating medium is effected by convection as in boilers of the ordinary type, and is subject to all the uncertainties that are to be anticipated in such boilers. While this arrangement may meet a need on European railroads and even possibly on railroads of this country, I do not look forward to any degree of success in stationary practice. The investment appears to me necessarily out of proportion to the rather questionable advantages.

In Fig. 15 is shown another suggestion. This is really very old, having been used in steam-driven automobiles thirty years ago

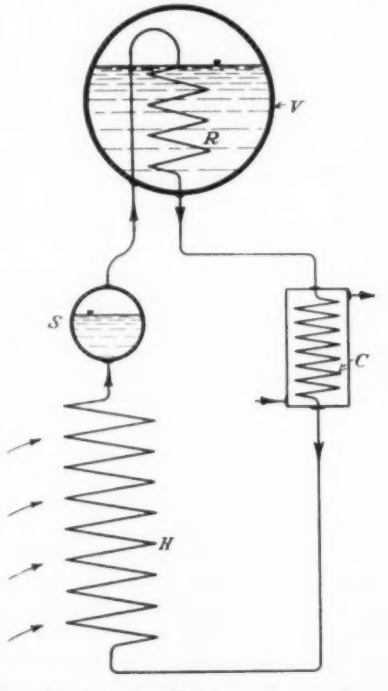

FIG. 14 SCHMIDT-HARTMAN STEAM GENERATING PROCESS
(S—Steam collector; C—Cooler.)

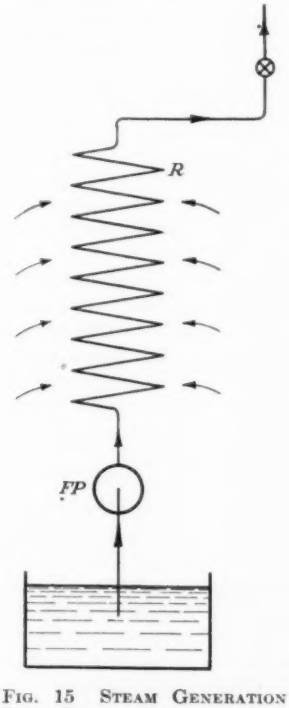

FIG. 15 STEAM GENERATION WITH FORCED CIRCULATION OF FEEDWATER BY MEANS OF PUMP
(FP—Feed pump.)

and being still in successful use for such purposes. It has never been very successful in large sizes because of the great difficulty experienced in properly coordinating the rate of water feed and the rate of combustion with the demand for steam. As there is practically no thermal storage in the device such coordination must be practically perfect, that is, instantaneous adjustment is required. Much work is now being done along such lines and great advances are being made, but I do not look for any great degree of success. On the other hand, I do believe that we are gradually preparing the way for a small-tube, forced-circulation boiler with ample thermal storage for use at high pressures.

THE BENSON BOILER

The diagram of Fig. 15 also serves as a schematic diagram of the Benson boiler which is well known through descriptive articles

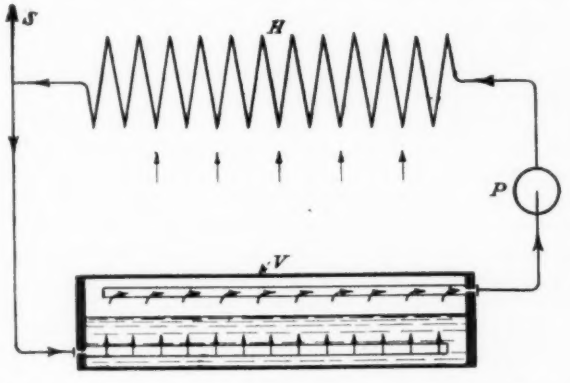

FIG. 16 STEAM GENERATION BY MEANS OF POSITIVE STEAM PUMPING
(S—Operative steam; H—Heated coils; P—Circulating pump; V—Vaporizer.)

in the literature. If the throttle valve above the heat-transfer coil be so arranged as to maintain a pressure above the critical, namely, 3200 lb. per sq. in., the water receives all its heat while in the liquid state and is converted suddenly and completely into steam after passing the throttle. The Benson type of plant has been tested very thoroughly over a period of several years by one of the large German manufacturers. That firm is satisfied with the results obtained and is endeavoring to sell plants of large size. In fact, a plant has just been ordered by an electricity supply company in Belgium. The capacity is quoted as 320,000 lb. of steam per hour.

I have examined the experimental plant twice and I have discussed its operation, control, and cost with its enthusiastic backers. I have not been able to become very enthusiastic about it and I should hate to be forced to put in such a plant today. I may, however, live to change my mind as I have done many times in the past.

THE LÖFFLER STEAM-GENERATING PLANT

In Fig. 16 is shown diagrammatically the type of plant invented by Dr. Löffler. All of you are probably familiar with it through descriptions which have appeared from time to time in the literature. I have discussed this plant with its inventor and I am certain that he will discover within the next few years many difficulties that he does not now dream of. However, he has had reasonable success with his first, small installations, and a plant of large size is now being installed on a commercial basis. I was at first very skeptical about the possible success of the Löffler principle, but of late I have begun to believe that it contains the possibility of success under American conditions. It will have to be modified greatly, but I believe that this can be done.

An interesting fact about the Löffler principle is shown in Fig. 17. The curve represents the work required to pump the steam, expressed as a percentage of the work which could be obtained by expanding in a condensing plant all the steam generated in the boiler. It will be observed that a pressure of 750 lb. is indicated

as a minimum for this type of plant, and that the efficiency increases rather remarkably as the pressure rises above that figure. I understand that Dr. Löffler contemplates operating in the neighborhood of 1800 lb.

There is another factor which must be considered in connection with high-temperature equipment. I have already spoken of the

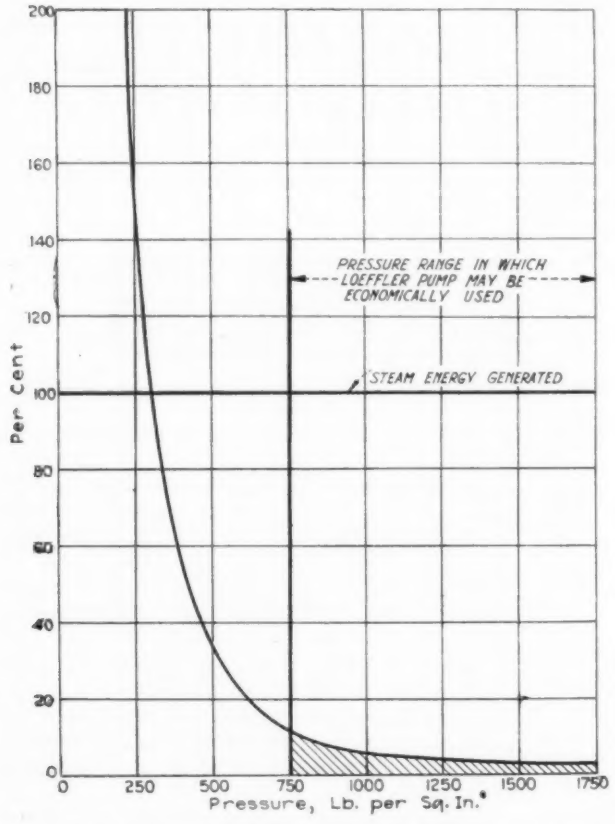

FIG. 17 RELATION BETWEEN ENERGY REQUIRED FOR STEAM CIRCULATING PUMP AND OPERATING PRESSURE
(Pump energy expressed as percentage of total steam generated.)

critical region which is approached in the case of boiler tubes, and particularly furnace-wall tubes operating at 1400 lb. Since the saturation pressure mounts with the steam pressure, it is obvious that the metal temperature of such tubes mounts similarly. The situation is just reversed in the case of superheater tubes. The effect of increasing steam pressure, with a given superheat temperature and all other things equal, is to reduce the metal temperature, obviously because of the greater density of the steam. This phenomenon plays directly into the hands of Dr. Löffler, who confines his high-temperature heat transfer to superheating surface. And it should be noted that the effect of pressure is particularly marked at high steam pressures with radiant-type superheaters, a feature essential to the success of the Löffler plant.

FURTHER PROGRESS CONTINGENT ON ABILITY TO OPERATE SAFELY AT HIGHER TEMPERATURES

It was suggested that I give you in this address some indication of work along new lines which would be of use to the industry and possibly of interest to you as scientifically trained engineering investigators. You will have learned from what I have already said that I believe our further progress in the improvement of power generation is largely contingent on our ability to operate safely at higher temperatures. Thus far this has been considered to be a matter of discovering new steel alloys capable of withstanding such temperatures "without creep." This view has been reached quite logically on the basis of published data. The curves of Fig. 18 will serve as an example. The long curves in the center represent data published by the U. S. Bureau of Standards. They were first published as "creep limits," but later explained as the unit fiber stresses which would cause 1 per cent deformation in 1000 hr. One of the lower curves represents similar data for a creep of 0.1 per cent in 1000 hr. I have added my best guess at the values for 1 per cent creep in the case of 0.13 carbon steel and 0.38 carbon steel.

You will note that unit fiber stresses between 2500 and 5000 lb. per sq. in. at 1000 deg. fahr. would appear to cause all these materials to creep at an alarmingly rapid rate. If you will do a bit of calculating you will find that such fiber stresses do not leave

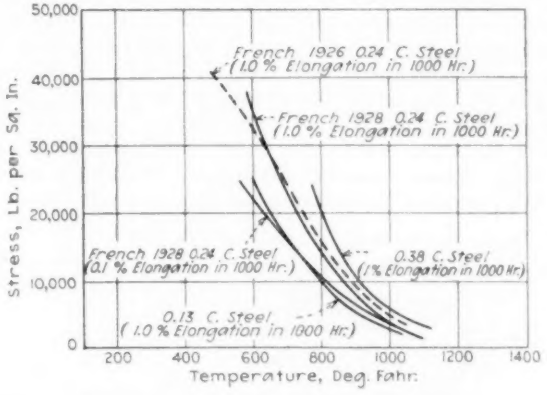

FIG. 18 DATA ON CREEP TESTS OF STEEL

many possibilities for high-temperature design at high pressure.

The company with which I am connected has sponsored an extensive research in this field during the past five years or more and is still far from the end of its program. I can tell you some things that may serve to start you thinking along new lines and possibly fire the imaginations of a few of you to the place where you will be willing to undertake constructive work in this field.

CREEP OF ALL METALS AT ALL TEMPERATURES UNDER ALL LOADS

It is popularly supposed that there is such a thing as a "creep limit." This is interpreted to mean that for each material at each elevated temperature there is a fiber stress which will not cause continuing deformation, no matter how long sustained. It is my present view that there is no such thing as a creep limit. It is also my present view that all metals creep at all temperatures under all loads. That probably sounds to you a bit revolutionary, but I am firmly convinced that it is true.

As I see things now, we always deal with the resultants of several different effects when we subject metal to strain. Speaking first of phenomena at normal temperatures with which you are all familiar, when we subject metal to strain we deform it. Experiment and experience show that we also "strain harden" it. Experiment and experience also show that by then elevating the temperature we can remove the strain hardening, that is, anneal it. It is also known that the rate of annealing increases rather rapidly with increase of annealing temperature.

From my present point of view this state of affairs represents a much more universally applicable set of laws than most of us have heretofore assumed. I believe that the relief of strain hardness

occurs naturally at all temperatures. It takes tens or hundreds or possibly even thousands of years in the case of steel at room temperature, but it does occur. Therefore, when we subject metal to continued strain of any magnitude and at any temperature, creep occurs. When strain hardening is automatically relieved at a rapid rate our present methods of test enable us to determine the fact that creep occurs; otherwise it does not appear to occur.

We are now advancing into a region in which we shall probably have to work with metal which creeps far enough and fast enough to make it necessary for us to recognize the fact. This need not worry us particularly because after all it is only necessary that any given part does not deform enough to terminate its usefulness before it has served a reasonable life. In the case of many parts of our equipment this requirement permits a very great degree of deformation.

A New Mechanics of Materials Necessary

Now tell me, which of you is able today to design machine or other parts on a creep basis and where would you obtain your basic data if you were able to? Some few attempts have been made to devise design formulas based on creep theories rather than the theory of perfect elasticity. They are exceedingly interesting, particularly because they turn the world more or less upside down.

For example, a thick-walled tube can withstand safely as much as 20 per cent more internal pressure according to the creep theory than it can according to the elastic theory of behavior. Again, according to the elastic theory, the transfer of heat inwardly through the wall of a tube subjected to internal pressure makes conditions worse with respect to the fiber stress in the tube wall, whereas according to the creep theory the results are practically opposite.

I firmly believe that we have now arrived at the place where we must devise and publish a new mechanics of materials and where we must perform the experiments required to produce the necessary design constants. I can assure you that it is no easy task, but I can assure you also that there is nothing impossible in it. I leave the suggestion with you, and I hope that it may strike a responsive chord in some of you.

Science and Engineering

RECENTLY, an important engineering journal wrote "The idea that engineering is based upon scientific knowledge is both wrongful and harmful, as it is generally understood. We had bridges before there was a theory of continuous girders and steam engines before there was any theory of thermodynamics." That engineering is an art demanding that creative ability and doing associated with art, as distinct from knowing in the strict scientific sense, is true, and it is also true that there were bridges and prime movers before there was any organized theory of structures or thermodynamics, but it does not appear true to say that there was any possibility of such bridges as the Forth Bridge, the Sydney Harbour Bridge, the Zambesi Bridge, and the Hudson River Bridge of 3500 ft. span, now in process of construction, before the birth of modern science and the scientific method.

Before Savery and Newcomen produced the first successful steam engine, many experiments on the pressure of the atmosphere, the relation between pressure and volume in gases, and the production and the condensation of steam, had been made by Porta, de Caus, Torrecelli, Papin, Boyle, and others; a group of students had gathered together in London, "inquisitive into natural philosophy," and from these gatherings arose the Royal Society; also Galvani had discovered voltaic electricity, with all its potentialities for engineering and the world. Seventy years after Savery's first engine was constructed, the greatest step in the development of the steam engine was made by James Watt, not surely as an invention in the ordinary sense, but as a splendid deduction from the quantitative knowledge of the latent heat of steam, obtained from the epoch-making experiments of Black and Watt, and the earlier work of Torrecelli, Boyle, and others on the pressure of the atmosphere; without these prior experiments it seems very doubtful indeed whether Watt's great invention of the independent condenser and the air pump would have been possible.

A little more than sixty years after Watt built his first steam engine, Michael Faraday, supplementing by his unique genius the experimental work of many who preceded him, discovered that a magnet could be made to spin round a fixed wire through which a current of electricity was flowing and a wire containing a current could be made to spin round a fixed magnet. Without these and other equally fundamental experiments, the wonderful developments of the generation and transmission of power which have taken place during the last fifty years, as well as the application of electricity to almost every need of the engineer, would have been impossible.

It is true that Carnot and Clausius came after Watt to perfect thermodynamic theory, and the modern theories of electricity were not known when Siemens made his first dynamos, but experimental and mathematical science had shown the way to engineering developments of the greatest significance to the life of the world. It has already been noticed that water wheels were known and used to raise water 2000 and more years ago, but in the seventeenth century water wheels were little different from those described by Vitruvius in the first century before Christ, and had efficiencies well below 50 per cent. In the latter part of the eighteenth century and the beginning of the nineteenth organized experiments on the flow of fluids had been carried out; relative velocities, momentum and kinetic energy were well understood; and the next step was made by Poncelet in 1832, who enunciated the guiding principles underlying the design of vanes receiving moving fluids, and from that time progress has been so remarkable that today water turbines of more than 70,000 hp. having efficiencies greater than 80 per cent are being constructed, and millions of horsepower are being generated by water power. The brilliant achievements in the development of the steam turbine of Sir Charles Parsons and others following in his steps are today well known. At the beginning of the nineteenth century there were probably 10,000 engines in England, giving a total horsepower of about 200,000. Today steam turbines each capable of developing more than 200,000 horsepower have been, or are being, made for stations in various parts of the world. It seems very doubtful if this could have been possible except as a consequence of the work of Poncelet and two centuries of scientific experiment.

Thus it can be said that the important steps that have been made in engineering during the last 100 years, and that distinguish this century from all the preceding, were commenced and made possible by fundamental discoveries of science, and it can safely be anticipated that no new epoch-making developments in the future will be possible unless preceded by new fundamental scientific discoveries. Prof. H. C. Lea in Presidential Address before Section G, British Associates, Johannesburg, S. A., Aug. 1, 1929.

Modern Labor Relations and the Engineer

A Plea for the Inclusion of the Study of Personnel Methods and Problems in the Curriculum of the Engineering School

By SAM A. LEWISOHN,[1] NEW YORK, N. Y.

I THINK I can best illustrate why I feel so strongly about the problem of the relations of engineering education to labor administration by describing one or two episodes having to do with recent industrial troubles featured in the press.

You will recall that there have been a series of strikes in the Colorado coal fields, and that the most recent one was reported as having been instigated by the I.W.W. The implication in some quarters was that the whole situation had been created by the I.W.W. leaders. I was discussing the subject with a very competent observer of the situation who had taken occasion to interview a number of the workers. He said that in talking with one miner who was a little more articulate than the others he had asked him point-blank if the I.W.W. was the chief factor in the strike. The reply of the miner, replete with profane adjectives, was significant. "Hell, no!" he said, "our managers, superintendents, and foremen were so foolish in their relations with us that the W.C.T.U. could have organized us."

No doubt you all have been reading about the strikes among the textile workers in Tennessee and North Carolina. I heard the situation described by one who had just returned from the vicinity and had talked with the strikers, and his observations were an interesting confirmation of what the press had in a general way described. He showed that the situation was largely caused by the efficiency engineers. In trying to increase the number of looms per man, they had utterly failed to take account of the human situation and the need for making the new conditions acceptable to the workers. They antagonized the workers completely, and the strikers had accustomed themselves to referring to these engineers as the "Minute Men." One story derisively circulated among the workers was that if a "Minute Man" should die and be taken to his grave by six pallbearers, he would jump out of his coffin and insist that there should be only four. In view of the fact that the efficiency engineers had not sold themselves or their ideas to the workers, their technical analysis may have been sound but their human salesmanship was faulty.

Both educators and business men must face new conditions which have arisen in industry. These conditions have two aspects: The first is that labor relations are of vital and increasing importance in industrial management; the second, that a large number of executives, an increasing proportion of whom are technical graduates, have no training in labor relations, and have no real background for such contacts.

Personnel relations are fundamental in all executive functions; they have become as fundamental in the engineer's daily work as physics, chemistry, and mathematics. Some means should therefore be developed for including training in labor relations in every technical curriculum, not to make the students personnel specialists but to give them a background in relationships with personnel. It is true that the pressure on the engineering curriculum is already great. There has been a rapid growth in technical courses in order to keep up with the demands for specialists. It seems to me that if some sacrifice is to be made in the curriculum, it should be in specialty courses of limited application. This subject is of such overwhelming importance that the sacrifice is not only justified—it is essential.

Labor Relations in the Hands of Operating Executives

More and more the maintenance of harmonious labor relations is left in the hands of operating executives. In our largest corporations there is a general tendency toward decentralization. The operating problems are left largely to the local production executives. This is the only sound course if big business is to be a success. Such decentralization is also found in the management of labor, because personnel problems involve direct, intimate, man-to-man relationships which cannot be governed at a distance except in broad essentials. It has often happened that efforts of "enlightened" directors or banking interests to promote effective, sound, and harmonious labor-relations policies have been delayed and nullified by lack of understanding and cooperation of the operating or local managers.

Local managers with a lack of background, who have no grasp of the fundamental politics of the situation in the best sense of that term, can make a great deal of trouble for a company whose directors and major executives at home are trying to persuade them to take a broad point of view. I recall a situation in Arizona where a strike had been called during the war by labor leaders, possibly under foreign influences. The strike was broken and the managers wished to punish a number of the men who had struck. If they had done so, they would have furnished ammunition to the discredited labor leaders. It was a rather interesting case in which the so-called absentee landlords were attempting to persuade the local management to assume a broader and more enlightened policy.

After all, what the stockholders, directors, and bankers want is stability of reasonable profits. They do not want any labor troubles which threaten this aim of all business endeavor. Business is not interested in any particular policy or theory or in "proving" anything—it wants efficiency and return.

It is for this reason that the generally prevailing idea that labor policies of corporations are controlled by boards of directors, by absentee stockholders, or by "Wall Street bankers," is, in large part, erroneous. Many instances can be given of corporations "controlled by the same interests" which have entirely different and sometimes diametrically opposite labor policies. For example, the Union Pacific and the Baltimore & Ohio railroads are controlled by the same banking group and yet have very different labor policies. The former, for example, does not deal with the unions existing among its shop craft workers; the latter has entered upon the so-called B. & O. plan, which is one of the most far-reaching examples of joint union relationships now existing.

Administrative Aspects of Labor Relations

The popular and prevailing idea that the differences and difficulties arising between employer (and management) and employee are due to the economic conflict of capital versus labor is also demonstratively erroneous, and, like many erroneous ideas, is dangerous. If wages and other economic factors were all there

[1] Vice-President and Treasurer, Miami Copper Co.

A lecture delivered at the S.P.E.E. Summer School for Mechanical Engineering Teachers, Purdue University, June 27 to July 18, 1929.

was to labor relations, we should not so often see two factories in a locality or industry paying the same wages, yet find one working smoothly while the other suffered from discontented labor. Nor should we see similar problems of conflict where no ordinary capital-labor relations can exist, as in Red Cross societies, government business offices, and consumers' cooperative organizations; nor should we see such problems in non-capitalistic Russia, where capital is presumably abolished. Labor relations are not only economic; they are also administrative.

To the concept of the "economic man" we must add that of the "administrative man."

There is nothing especially mysterious about harmonious labor relations, for to a large degree they are based on known principles. Their successful application depends on the attitude of the managers far more than it does on the attitude of the employees. If there is a general social bitterness among the employees it can, in most cases, be overcome by skilful management. I know intimately the case of a certain plant where one manager, who was having a good deal of trouble in getting cooperation from his working force, was succeeded by another manager who made an outstanding success with exactly the same group of men.

This particular manager has shown a great deal of ingenuity in his method of achieving results. To give an example, he raised wages recently without waiting for the men to ask for a raise. At the same time, to justify his action to headquarters, he told the workers that he had allocated a certain amount of the raise to each department, and that he did not expect the raise to show in the departmental costs, as he hoped the men would make up for the raise by increased effort. Thus, he said, he could prove to his superiors that the raise had cost no money. The men entered into his plan with such zest that the departmental costs have shown no increase despite the raise in wages.

This same manager developed a safety-first campaign. One feature of this work was the plan of having the factory whistle blow on each day that no accident occurred. This has aroused the sporting instincts of the men and the question of whether the whistle will blow or not on any day has become an outstanding event in the rather isolated community. The accident rate has decreased notably.

You may say: But this is something for the specialized personnel manager. It is only to a limited and routine extent, however, that personnel relations can be placed in the hands of personnel managers. There are a great many matters of policy which must be decided by the manager himself. Moreover, the proper attitude must pervade all executives, and all must have a trained understanding of at least the principles of sound personnel relations.

For example, there is the broad problem of justice. In a mine with which I am acquainted there fortunately exists an excellent morale. The following example of the policy pursued explains why this favorable situation exists. The superintendent of one of the departments, a valuable but excitable man, was angry with a workman over a mistake that he had made. In his excitement he grasped the workman by the arm. The latter misunderstood. A rough-and-tumble fight ensued. The manager of the mine suspended the offending superintendent, and, in spite of the willingness of the workman to drop the incident, insisted on a formal apology. In another mine, a subordinate department head discharged an engineer who had wrecked an important machine by careless manipulation. In replacing this man he skipped the brother of the discharged engineer, who was next in line for promotion. It looked as though the executive were punishing the man for the faults of his brother. It appeared certain that this step would create a great deal of resentment. The manager promptly overruled the act of his assistant, risking the loss of a valuable executive member of his staff in so doing. It is this sort of fairness that is fundamental in any sound administrative system.

I am not, of course, denying that such specialized work requires functionalization and that one of the first steps of a managing executive that understands this problem is to put in an adequate personnel and employment department. The manager cannot attend to the details of many personnel matters any more than he can attend to the details of any other technical or administrative aspects of his business.

Engineering Graduates as Administrators

In this age of the manager, it is extremely significant that more and more executive responsibility is being turned over to technical-school graduates. These positions include not only those directly concerned with the application of engineering technique, such as design, construction, and production supervision, but also positions of broader and more general responsibility. Recent figures show that probably 67 per cent of the graduates of engineering schools find themselves ultimately in managerial and administrative positions.

This is a great tribute to technical education. Business recognizes that the engineering educator has faced the facts of industry and has successfully undertaken to train men in the technique of the control of the mechanical and scientific processes of industry.

Will the engineer with equal success meet the urgent need of industry for executives who understand and have learned the principles of the management of men?

Many instances could be cited of individuals admirably trained in a technical way who, in promotion, were passed over in favor of men with perhaps less scientific ability but more administrative ability. I remember one case in particular where a young man, a mechanical draftsman, had made an outstanding success in a specialized field and was considered by his superiors for a promotion to an attractive managerial position, but was rejected because he did not possess the managerial ability.

Mr. Owen D. Young emphasized the need for such capacity very strongly at a recent discussion with a group of engineering educators and industrialists in New York. He said that in his own company it was hard to find engineering talent able to take attractive positions of "general command," as he termed it. Likewise, Mr. Hoover, in discussing this problem a few years ago at a small gathering, spoke of this same difficulty of finding, in a small business in which he was interested, a man who combined with a knowledge of the "art" and the technique of the industry the capacity and ability to organize human beings.

The engineering student has a right to expect that he will be fitted to assume the responsibilities thrust upon him in the course of his work—at least to have the necessary "background" so that he can adapt himself to them. In the technical phases, engineering education has been adequate; in the management phases, particularly in relations to labor, many graduates have found themselves sorely handicapped by lack of knowledge of the elementary principles of human administration. For the training of engineers is largely in the mathematical manipulation of precise formulas relating to concrete materials. Human relations do not permit of such precise measurements, but there is an art of human administration in the factory, the elements of which could be taught to the engineering student. In order to become a capable engineer useful to society, it is necessary that he acquire this precise training. But it is also necessary that he come to understand that there are fields in which he will necessarily function in which it is not possible to use a footrule.

Some people despair of training in this field, because they have the idea that leaders are born and not made. This is as unten-

able as the idea that engineers are born and not made. To be an effective leader of men, an executive in the administration of labor relations requires training just as the engineer requires training. Native ability along either line can be developed to practical success by proper training. It requires an objective study of the problems involved, knowledge of sound personnel methods used, understanding of fundamental principles.

Mere latent "qualities of leadership" are not enough. In too many cases such born capacity is entirely frustrated and distorted because of absence of real interest in human problems. Because some managers get along easily with employees is the very reason why they depend on that ability to carry them blindly through any trouble.

I remember a manager in one plant who, although a man with an attractive personality, failed to develop the possibilities of his working force because of a lack of interest in human organization problems. His training had made him more intellectually interested in assaying than in problems of administration. He turned around to me one day and said, "Oh, Mr. Lewisohn, you people in New York overemphasize personnel matters." Since then he has seen the limitations of his point of view and has given much more attention to these problems. The results he has achieved in production have shown very definitely the value of this enlarged perspective. For instance, the problem of relations between the employment department and the foremen, which is a very delicate one, has been worked out in collaboration with the shop committee composed of elected representatives of the men. This manager meets his shop-committee representatives, that is, the representatives elected by the men, once a month. He is so much interested in this aspect of administration that he thinks this meeting with the representatives is the best method of keeping in close touch with the situation himself.

Once a man enters industry, however, he is likely in most cases to absorb very soon the prevailing ideas of "how to handle men." In this way he too often takes on whatever prejudices and colored attitudes he finds around him. His methods become simply a perpetuation of old methods—often inadequate or perhaps positively harmful. It is then too late for him to "pick up" the technique of personnel administration.

Basic Training in Labor Relations Should Be Given in Engineering Schools

Therefore the basic training in labor relations should be given during the formative period of the future executive's career. In other words, it must be started during his college years. It is then that the psychology of the student is most like wax. It is his "impressionable" period. His professional training acquired at that time affects his entire outlook. It seems to us industrialists unfair to ask us to train such men at forty, when their minds are set. They should be trained at twenty, when their minds are flexible.

Such courses of training have already been successfully developed and are being applied in some of the leading engineering schools. There is a growing body of sound and helpful material for such courses, and in addition to the content used, a number of methods have been devised to make the teaching more effective.

As an instance, one professor in an engineering school has developed a technique for teaching men how to deal with an individual workman in certain given situations. He rehearses with his students cases in which they give orders to difficult workmen, and the causes of their resentment are analyzed. The scene is laid in an actual setting, as if the problem were occurring in a real shop.

Personnel relations are fundamental in all executive functions; they have become as fundamental in the engineer's daily work as physics, chemistry, and mathematics. Some means should therefore be developed for including training in labor relations in every technical curriculum, not to make the students personnel specialists but to give them a background in relationships with personnel. It is true that the pressure on the engineering curriculum is already great. There has been a rapid growth in technical courses in order to keep up with the demands for specialists. It seems to me that if some sacrifice is to be made in the curriculum, it should be in specialty courses of limited application. This subject is of such overwhelming importance that the sacrifice is not only justified—it is essential.

It is not suggested that more than an elementary course be given in this subject. The student should get just enough to give him some little background in the history of labor, industrial psychology, the history of trade unionism, and similar socio-economic problems which will aid him to understand the special psychology of the worker. He should also have some elementary idea as to the proper methods of employing, placing, training, and promoting employees, securing their cooperation through employee shop committees, the handling of grievances, reducing fatigue, the proper place of a personnel department in the factory, the training of foremen, and safety and health programs. It is only necessary to present the first principles of these matters, just enough to awaken the student to their importance, so that he will at least get the "hang" of approaching them and an interest in "boning up" on them in his future career.

The important thing, as I see it, is that this instruction be given not as an incidental course to other courses, but as an integrated course that will duly impress the subject upon the young student as a problem of the first magnitude. No matter how attractive a personality a student may have, he should also have a thorough understanding of labor relations and some knowledge of the actual technique of labor administration. An interest in the art and science of labor administration should therefore be made professionally fashionable among future engineer managers.

Industry must have the right kind of managers—it means the difference between failure and success. If business cannot rely on the managers it gets from engineering schools, it will get them from other sources. New courses of training will be developed outside of the engineering schools. Engineering graduates do not want to find promising and lucrative positions out of their reach because of a defect in their preparation.

Atomic Energy

VISIONS of engineers' controlling sources of atomic energy immeasurably more powerful than those available at present sometimes come to the hopeful, inspired by the developments of experimental and mathematical physics. It may be, and until man is more worthy at least it is hoped that it will be, impossible for atomic energy in large quantities to be obtained and controlled. Also it may be equally impossible to obtain energy by the synthetic building up of other elements from the fundamental element hydrogen, which can be obtained in abundance by the electrolysis of sea water, but whatever the future has to unfold it seems certain that only by following the new ways opened by pure science can there be hope of success. Perhaps it may be that not along this path that modern physics seems to suggest will the new knowledge come; but, as many years ago there came the new and wonderful discovery of voltaic electricity while Galvani was making experiments with frogs, so in the future a biologist or chemist or physicist, working on some subject entirely remote from the production of energy, may make discoveries which the Watts and Faradays of the future may use to change the life of the world.—Prof. H. C. Lea in Presidential Address before Section G, British Association, Johannesburg, S. A., August 1, 1929.

Materials in Machine Construction

Some Fundamental Concepts and the Importance to Machine Designers of Certain Properties of Materials

By H. F. MOORE,[1] URBANA, ILL.

THE designer of machines, in searching for allowable values of load and size of parts, must have recourse to values assigned to properties of materials as the result of tests of those materials. It is a very easy matter for the testing engineer who makes the tests to become so interested in the technique of his testing that he loses sight of the significance of his test results. A striking example as an illustration of this is found in the multiplicity of methods used for determining a value called elastic limit, and the general disregard of the differences in significance of the various breeds of elastic limit. On the other hand, the designer frequently accepts test results uncritically, without much thought as to their significance as indices of resistance to the kind of forces set up in the machine he is designing. Both testing engineer and machine designer should pay much more attention to the significance of the test results obtained in the materials-testing laboratory.

Strength Properties of Materials

The strength properties of materials have a direct quantitative relation to the constants used in the formulas for machine design. The strength values, elastic limit, yield point, tensile strength, and fatigue strength, all are experimentally determined values, determined from tests.

The action of the particular testing machine used is of the same general nature as are the service loads on the machine. In this connection it should be noted that the problem of design always involves two general questions, and two distinct viewpoints: (1) In practice, what loads will come upon the machine? This question cannot be answered by any laboratory tests, but must be answered by a study of service records and of service conditions. (2) What stresses will the material in the machine parts withstand without failure? This question is, in general, answered by laboratory tests, although it may be answered more slowly, and perhaps more satisfactorily, by slow and costly experience.

Tensile Strength. The tensile strength of a material is the maximum stress it will withstand before being actually pulled in two. As commonly determined the value for tensile stress is a nominal value obtained by dividing the maximum load carried in a test of the specimen by the original area of cross-section. The tensile strength is obviously of direct significance for designing bolts, chains, wire rope, etc. which are to resist dead load, or load repeated but a few times. However, in many cases a stress far below the tensile strength will cause practical failure of a part through excessive distortion. This is discussed in the next paragraph. Oddly enough the tensile strength for a metal is frequently a fairly good index of its ability to withstand repeated stress, although the ratio of limiting load under repeated stress to tensile strength varies all the way from 0.20 to 0.60 for various metals.

Elastic Strength. The term elastic strength is here used as a general term to indicate the limiting strength of a material before serious permanent distortion occurs. Under the head of elastic strength there may be considered the significance of elastic limit, proportional limit, and yield point. The direct significance of elastic strength is that it is an index of ability to resist permanent distortion. For metals under steady loads, or loads repeated but a few times, elastic strength is probably the most important index for the machine designer. Elastic strength is not an index of resistance to repeated stress. An idea which has grown up naturally from our use of the theory of elasticity is that for each material there is a limiting stress below which the metal is perfectly elastic. It is doubtful whether this is strictly true for any actual material. Extremely delicate machines will usually reveal some inelastic action under very low loads. The limiting elastic strength depends on the arbitrary assumption of how great inelastic action must be before it does appreciable damage.

There are in use three terms to define elastic strength. These are: (1) elastic limit, defined as the limiting stress when permanent distortion first appears, (2) proportional limit, defined as the limiting stress at which there occurs an appreciable deviation from Hooke's law (stress proportional to strain), and (3) yield point, which is defined as the limiting stress at which an increase in strain takes place without an increase in stress. In the opinion of the writer, the significance of elastic limit and proportional limit as indices of elastic strength have been greatly overestimated. On the other hand, yield point, where it exists, clearly is an indication of very appreciable inelastic action. The writer believes that it would be a desirable development if the terms elastic limit and proportional limit were to disappear from the phraseology of the machine designer. The writer suggests that yield point be defined as "the limiting stress for a material at which appreciable inelastic action becomes evident" and that the term yield point be then used as the index of elastic strength. Proposed arbitrary methods of determining a practical yield point are many, but there is not space for the discussion of them here.

Shearing Strength. The importance of shearing action in machine and structural parts is frequently underestimated by the designer. Shearing strength is of direct significance for shafts in torsion, rivets, and short-span beams. It must always be remembered that the shearing strength and the tensile strength for a material are not the same. In ductile materials the shearing elastic strength is usually much less than the tensile elastic strength. In brittle materials, the ultimate shearing strength is usually equal to or greater than the ultimate tensile strength.

Microscopic study of metals indicates that the nature of shearing failure is quite different from that of tensile failure. Shearing failure seems to consist of a sliding of thin laminae of the material. Unless the shearing stress is repeated many times, there does not seem to be much if any actual tearing apart of the material, but rather a marked sliding distortion. Today there is a view held by many materials engineers that all elastic failure is essentially a shearing failure, while actual fracture is a tensile failure. The determination of shearing elastic strength and shearing ultimate strength is not nearly so well standardized as is the determination of tensile strength. Shearing elastic strength can best be determined from torsion tests of a hollow circular specimen. Shearing ultimate strength can best be determined by a torsional test of a hollow, round specimen with a very short reduced section.

Compressive Strength. The compressive strength is of direct

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A lecture delivered at the S.P.E E. Summer School for Mechanical Engineering Teachers, Purdue University, June 27 to July 18, 1929.

significance in short machine parts subjected to pressure and also in connecting rods, piston rods, and structural columns. Elastic failure under compression seems to be of the same nature as elastic failure under tension and to be due to shearing on an oblique plane. Compressive ultimate strength is not well defined for ductile metals, and in the case of brittle metals and most non-metals it seems to be a shearing failure, or else a tensile failure due to the lateral strain at right angles to the compression. For ductile metals the yield point is the practical ultimate in compression, especially the compression of short columns and those of medium length. If the yield point is exceeded in tension the piece tends to "straighten out," while in compression if the yield point is exceeded the piece tends to buckle and to collapse. Hence elastic failure is more serious under a compression load than under a tension load. The question of column strength is treated at length in all texts of the mechanics of materials and it is to be noted that we are still depending upon empirical constants

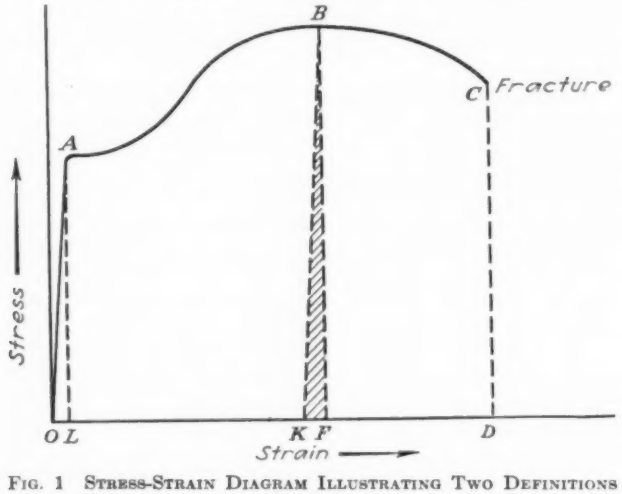

FIG. 1 STRESS-STRAIN DIAGRAM ILLUSTRATING TWO DEFINITIONS OF "RESILIENCE"

Definition 1: Resilience up to stress *BF* measured by area *OLKFBA*.
Definition 2: Resilience up to stress *BF* measured by area *BKF*; *BK* is stress-strain line for release of load.
Both definitions: Elastic resilience measured by area *OAL*.
Suggested nomenclature: "Toughness" is measured by area *OLKFDCBA* —area under complete stress-strain diagram.

determined by experiments to get the actual values of strength of columns.

Compressive elastic strength can be best determined by tests of short cylindrical specimens.[2] For ductile metals compressive ultimate strength cannot be determined, and for brittle materials it is best determined by tests of short cylindrical specimens.

Impact Strength. The word "impact" is one of the mystery words of the mechanics of materials. Whenever we have a moving machine part we are prone to assign any unexplained failure to "impact." Actually impact is merely rapidly applied load. It is impossible to conceive of an actual load being instantaneously applied to an actual elastic machine part. A great difficulty in figuring stresses due to rapidly applied load lies in the fact that when a load is moving and comes in contact with a machine part the stresses set up depend entirely upon the deformability both of the moving mass and of the machine part. We can figure the energy in a moving body, but we cannot figure "the force of the blow" which the moving body strikes unless we know the yielding both of the moving body and of the anvil. Energy is measured in foot-pounds or inch-pounds, and applied forces are measured in pounds. Hence we can see that we can not correlate the two directly—their units are different.

[2] A cylinder with length twice to three times its diameter makes a satisfactory compression specimen.

In connection with impact, it should be noted that there are in use two distinct definitions of the term "resilience." One definition defines resilience as the total amount of energy expended in developing a given stress in a machine part. The other definition defines resilience as the amount of energy which can be *recovered* after the stress on a machine part has been brought to a certain value. So long as the action is purely elastic, the two definitions define the same value. Fig. 1 illustrates the two definitions. The writer believes that the second definition is preferable.

In connection with the determination of impact strength there has come into rather wide use the notched-bar impact test, in which a notched bar of metal is broken in cross-bending by a swinging pendulum, and the energy required to fracture a standard-sized specimen is determined from the angle of rise of the pendulum. This test is an excellent example of a very carefully developed test whose significance is decidedly uncertain. The test does not furnish a measure of the strength of the material either under dead load or under repeated load. Probably the effect of shape of notch is more important than the fact that the load is rapidly applied.

A few tests have been made in which the force applied under rapid loading was measured, usually by the deflection of a very stiff spring or the elastic stretch of a long steel bar. These tests in general show that, under extremely rapid loading, load applied in, say, one-twentieth of a second, there is, at least for steel, a distinct increase in strength with increase of rapidity of loading. For steel this increase is very small except for extremely rapid loading. The softer metals show more effect of speed, as do most of the non-metals.

STRENGTH UNDER REPEATED LOADING; "FATIGUE" STRENGTH

Probably the majority of structural failures which occur in machine parts are due to the action of loads repeated very many times. Under repeated stress materials sometimes fail under loads which can be borne a few times without injury. The failure is usually sudden, and even in a ductile metal the part snaps off as though it were brittle. It was formerly supposed that under repeated stress some metals "crystallized" and became brittle at the junction of the crystals. Modern investigation with the microscope has discredited this theory, and it is seen that such a failure under repeated stress is due to a spreading of a minute crack. The term "fatigue of metals" is commonly applied to this phenomenon, but the term "progressive fracture" would be better. At the present time the best index to resistance to repeated stress is known as the endurance limit. The endurance limit is determined by subjecting a series of specimens to repeated cycles of stress of varying intensities, plotting a diagram with maximum stress as ordinates and number of cycles for failure as abscissas. If the tests are carried out to, say, 100 million cycles of stress for nearly all metals this diagram becomes horizontal and the stress corresponding to the horizontal part of the diagram is known as the endurance limit. (See Fig. 2.)

The commonest repeated stress test is the test of a specimen under reversed bending action. For "fatigue under non-reversed loading" the following formula expresses rather roughly the relation of endurance limit to range of stress during the cycles:

$$FL = \frac{3FL_{-1}}{2 - r}$$

in which

r = the ratio of (numerically) minimum to maximum stress for each cycle of stress (r is negative for reversed or partially reversed stress)
FL = the endurance limit for any range of stress
FL_{-1} = the endurance limit for completely reversed stress ($r = -1$).

It should be noted that this formula should never be used for working stresses above the yield point of the material, else the piece is in danger of elastic failure rather than progressive fracture.

It is often thought that the endurance limit or fatigue strength of a material is coincident with the "true" elastic limit. Experimental study throws doubt on the existence of any "true" elastic limit and shows very little correlation between the endurance limit and any elastic-strength values determined by laboratory tests. There does seem to be a correlation between fatigue strength and ultimate tensile strength. This is reasonable enough when it is considered that fatigue failure is a progressive fracture.

To the machine designer, perhaps the most important consideration in connection with fatigue failure is the importance which it gives to localized stress over minute areas of a machine part. Under steady load, the stress over a small area (e.g., the bottom of a screw thread) may be well above the yield point of the material and, for ductile material, no harm will be done. The permanent distortion affects so small a part of the machine member that it is inappreciable in its damaging action. Under repeated stress such an overstressed minute area may serve as a nucleus from which a fatigue crack spreads. Every machine designer should take as his slogan, "Look out for localized stress." Avoid nicks, sharp shoulders, and notches; under repeated stress remember that at the bottom of a screw thread the stress is probably three or four times load divided by area.

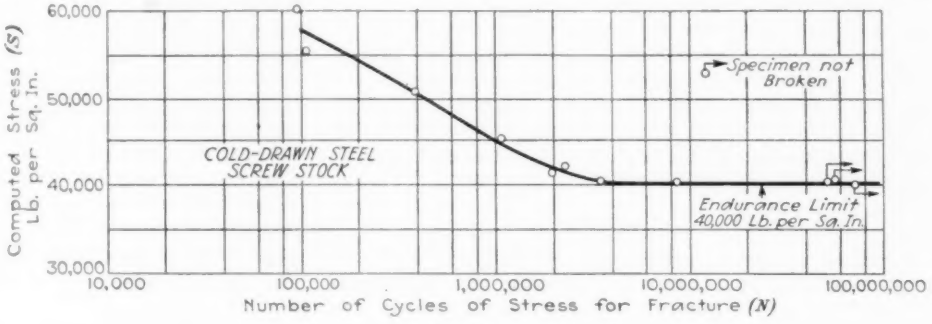

FIG. 2

In connection with this study of localized stress, a very striking fact has been brought to light. All our formulas for mechanics of materials are based on the assumption that material is homogeneous and that it can be divided up into small parts without change of properties. Microscopic examination shows that this is not true. When we consider localized stress, we consider areas so small that the varying strength of different crystalline grains of metal, or of different fibers of wood, begins to become important. Another thing to be noted is that the danger produced by localized stress is relatively more severe for the finer heat-treated metals than it is for the cruder metals. Notches, sharp shoulders, and grooves do very little damage to cast iron—the damage has already been done by the graphite flakes in the iron; but such defects do a great deal of damage to heat-treated alloy steel. The endurance limit and the existence of localized stress are factors of prime importance in parts made up of the finer grades of metal. In this connection it should be noted that a poor surface finish may reduce the fatigue strength of a part by as much as 20 per cent.

A recent development in the science of materials is the discovery that under the simultaneous action of repeated stress and a corrosive agent, tremendous damage may be done to a material. The simultaneous action of repeated stress and so mild a corrosive agent as fresh water may reduce the fatigue strength of heat-treated alloy steel until it is no better than ordinary, cheap steel. The machine designer must look out that his parts are not subjected to moisture while they are under stress. A coating of rubber cement or even a heavy coating of grease seems to be a fairly good protection. The corrosion-resisting properties of stainless steel are probably due to the fact that the surface corrosion forms a thin, strong film which can resist considerable stretch without cracking.

HARDNESS

The term hardness in popular usage has several different meanings. It may refer to resistance to indentation, to resistance to scratching or cutting, or to elastic stiffness. Its common technical meaning is resistance to penetration. There are a number of tests to measure this quality, the best known being the Brinell test, in which a hardened steel ball 10 mm. in diameter is pressed against the surface of the metal to be tested with a standard force (usually either 500 or 3000 kg.). The resulting diameter of indentation is measured and a hardness number assigned by dividing the load by the spherical area of the indentation. Various other tests such as the Rockwell, the scleroscope, the Vickers, and the Herbert tests are used, depending upon the indentation principle. The hardness thus determined is usually correlated with the tensile strength and with the fatigue strength of the material. The quantitative relation between hardness number and other strength properties varies for different metals. Hence some idea of the strength of a material can be obtained from a non-destructive hardness test. In selecting and testing materials for machine parts, the hardness test is coming into very wide use. Most automobile manufacturers run a hardness test on every crankshaft produced, and reject those which fall outside certain limits of hardness.

In general, the harder the material, the more resistant it is to abrasion, but there are many exceptions to this statement. Manganese steel, such as is used in railroad frogs and crossings, does not show a particularly high Brinell hardness, yet when abrasive action occurs, the character of the steel is changed so that it does not proceed very far until it forms a protective coating of hard steel over the parts below. At present there is no well-defined test for resistance to abrasion. One is very much needed.

In general, the higher the hardness number of a metal, the more difficult it is to machine, but again there are exceptions. The machining of metal is more or less of a shearing action, and hardness and shearing strength do not always go together. There is no standard test for machinability, and one is much needed.

DUCTILITY

Ductility is regarded as an important property of metals used in machine parts, but it has no direct relation to the constants used in formulas for design. Ductility is really an insurance factor against injury by occasional overstress. It would be very difficult to erect a structure out of cast iron. Any attempt to bend the cast iron into place, to line up rivet holes, etc., would probably lead to fracture. Moreover, ductility is an insurance factor against shattering failure. No one would think of making a crane hook out of cast iron. The common indices of ductility

are the measurement of elongation and reduction of area at fracture of a tension-test specimen, and the angle through which a piece can be bent cold without showing cracks. A new test for ductility proposed by A. B. Kinzel[3] bends a piece cold and measures the percentage of stretch on the convex surface when a crack first appears.

Mr. Kinzel of the Union Carbide and Carbon Laboratories has recently proposed a formula for allowable stress in steel which takes into account the ductility as measured by some of the foregoing tests. This is a very interesting formula and it would seem entirely logical to allow somewhat higher working stresses in a material whose ductility safeguards it against sudden shattering failure under an accidental overload.

Ductility has no direct effect on fatigue strength. The fatigue strength of hard, brittle spring steel is much greater than that of soft, tough structural steel. For members subjected to reversed stress, probably ductility is not a very important quality, since the stretch in one direction is offset by the stretch in the other, and very little permanent set occurs to give opportunity of "evening up" of stress distribution under succeeding cycles of loading. For members subjected to repetitions of stress in one direction, the tendency to form cracks at points of localized stress may be somewhat neutralized in a piece of ductile metal by the plastic stretching at that point, so that under repetitions of one-way stress, ductility would be of distinct advantage.

Toughness

Toughness is a term not regarded as standard in technical descriptions of materials. The writer, however, believes it would be a good term as indicating combinations of ductility and strength. He believes that the toughness of the metal might be measured by the area under the stress-strain diagram of a specimen. Toughness would then be a measurement of the energy required to pull the metal in two.[4] A comparison of strength, ductility, and toughness is furnished by a consideration of the action of lead, steel, oak, and cast iron. Lead is ductile, but very weak; it could not be called a tough metal. Structural steel is ductile and is also strong; it is emphatically a tough metal. If two beams of the same size, one of oak and the other of cast iron, are tested under static loading, the cast iron will be found to be the stronger. If they are tested under impact loading, the oak will absorb the greater energy before rupture. The cast iron is stronger than the oak, but the oak is tougher than the cast iron.

Tenderness

In using the term "tenderness" the writer again is using a term not recognized as standard in technical discussions. In connection with the study of fatigue of metals and the effect of such local "stress raisers" as grooves, notches, etc., it was soon found out that the amount of damage done by such stress raisers varies widely for different metals. In general, very pure metals and very fine-grained metals were most affected by such stress raisers. Such metals might well be spoken of as "tender," and the general fact should be regarded that in general the higher the quality of the metal, the greater its tenderness. Heat-treated alloy steel or duralumin must be machined and finished much more carefully than is necessary for cast iron or a cheap grade of steel. Physicists tell us that if we develop the full cohesive strength of our metals, we can expect from ten to twenty times the tensile strength we now obtain. Whether the reason for this discrepancy lies in surface defects or in minute submicroscopic defects scattered through the metal, is not certain, but we are very far from the perfect metal today. If we could ever get a perfect metal, it would probably be extremely tender. The English physicist, Griffiths, succeeded in getting fibers of glass which developed near their full cohesive strength, but left in the air of the laboratory for a few days, they lost over 90 per cent of their strength.

Resistance to Corrosion

Probably the losses of engineering materials due to corrosion mount up to at least $100,000,000 a year in the United States alone. Corrosion is gradual in its action and rarely causes any dramatic, disastrous failures in structures inspected with any degree of care. However, the cost of corrosion is very heavy indeed. While the corrosion is bad enough in unstressed metal, it is always worse in highly stressed metal. The effect of simultaneous corrosion and repeated stress has been discussed in a foregoing paragraph. The effect of a steady stress acting together with corrosion is less disastrous than is the case for repeated stress, but the corrosion of stressed metal is markedly worse than the corrosion of unstressed metal. The commonest protection against corrosion is painting. Painting to be effective must be periodically renewed. Furthermore, if corrosion has started it will proceed beneath the coating of paint, hence it is important to clean surfaces thoroughly before they are painted. Localized corrosion sometimes leads to deep pitting, and this may take place in a painted surface at cracks. Where feasible a thick coating of concrete is as effective as an inhibitor of corrosion. Plating of corrodible metals with corrosion-resisting metals is an effective way of inhibiting corrosion. Zinc, nickel, cadmium, and chromium are used as protective coatings.

The recent development of the so-called stainless irons and steels is of great interest. All the stainless irons and steels carry high percentages of chromium (up to 16 per cent). This material is coming into wider and wider use every day, and when the cutting, machining, and welding of it have been perfected, its field of usefulness will be still wider.

In general, the bronzes (copper-tin alloys), the brasses (copper-zinc alloys), and copper-nickel alloys such as monel metal are much more resistant to corrosion than are steels. Of the light metals, aluminum is fairly resistant to corrosion; duralumin, the alloy of aluminum and copper, sometimes is subject to a particularly disastrous corrosion which proceeds along the boundaries of the crystalline grains. A recent development in plate material is a thin duralumin plate coated on both sides with pure aluminum.

Heat Treatment, Mechanical Treatment, Time, and Moisture Content

It is obvious that in choosing materials for machine parts, we cannot rely on chemical composition alone. A piece of steel containing 0.40 per cent carbon, heat-treated, will be stronger, and probably more ductile than a piece of steel containing 0.90 per cent carbon annealed. The presence of certain undesirable ingredients may be detected by chemical analysis as may the presence of other ingredients which, under proper heat treatment, may add to the strength of the metal.

Heat treatment is the means by which probably the greatest changes in the strength properties of materials can be brought about. Between an annealed condition and a quenched condition the strength of a chrome-nickel steel may be tripled. Under heat treatment, duralumin is converted from a rather brittle, weak material to one of the strength about equal to structural steel. More and more it is becoming necessary to consider very carefully the heat treatment of all machine parts. It should be noted, however, that for steel parts the elastic stiffness (as measured by the modulus of elasticity) is not changed by heat

[3] Proceedings A.S.T.M., 1929, Part 1, Report of Committee E-1 on Methods of Testing.

[4] It should be noted that some writers speak of the quality measured by area under the stress-strain diagram as resilience. (See Fig. 1.)

treating. Ordinarily there is very little gained by making the spindle of a lathe or a boring mill of alloy steel. The spindle is amply large for strength, and its elastic stiffness is as great if made from ordinary machine steel as if made from alloy steel.

The strength properties of steel and of the non-ferrous metals may be markedly changed by cold rolling or cold drawing. Cold drawing greatly increases the elastic strength of a metal, and increases the tensile strength and the fatigue strength to a somewhat less degree. Some non-ferrous metals show very little increase in fatigue strength due to cold rolling, while their elastic strength is increased four or five times. The possibilities of increasing strength by cold working are limited by the fact that severe cold working starts cracks in the material. A very interesting application of cold working is the Hultgren treatment of steel balls and ball races. Steel hardened by heat treatment is still further hardened by cold working.

One of the striking developments of recent years has been that of fusion welding processes for metals. A fusion-welded joint is a casting, and, in general, cast metal is weaker and less reliable than rolled or forged metal. This is especially true under repeated stress and under impact load. Where the welding is done in large shops with special apparatus and close supervision, the static strength of a welded joint runs up to something like 80 per cent, or better, of the strength of the base material. Data are few as regards the fatigue strength of welded joints, but even under carefully controlled conditions it would not seem safe at best to regard the fatigue strength of a welded joint as more than 50 per cent of that of the base metal. When it comes to field welding made by ordinary small welding shops, the strength should not be considered as more than one-half the values given.

When we consider the non-metallic metals, timber, rubber, concrete, textiles, etc., we find two new factors affecting the strength. The first of these is the tendency to gradual failure under steady load. Usually in the metals, except possibly for the very soft metals, no account of time effect under steady load need be made,[5] but for the non-metals the time effect is always appreciable. Timber will sometimes fail under a long-continued load of only 50 per cent that developed in an ordinary testing machine test. The same is true to a less degree for other non-metallic materials. When we come to timber and the textiles, the moisture content has a marked effect upon the strength. For timber used under ordinary conditions it is probably safest to regard its strength as no greater than that of green timber due to the fact that it can readily absorb moisture from the air. The same would be true of textiles.

Cost

Of course the economic side of the choice of materials for machine parts is of great importance. With the cost of metals varying so from month to month and from year to year, only general considerations can be given. In general, for small light machinery, the cost of a material is a minor factor, while the cost of machining and erecting is a major factor. As an illustration in the manufacture of hydraulic presses, for presses below a capacity of, say, 20 tons, the cost of material would probably be a minor consideration. For presses above 100 tons, the material would probably be the major consideration.

What Makes Buildings Costly

THE author points out that, in the first place, the cost of a modern building cannot be compared directly with that of a building erected many years ago because the character of construction has changed and many features have been introduced which add to the cost of construction. In general, however, he claims that it is not high wages but wasteful and inefficient methods that account for the greater part of the excessive cost of building.

Improper types are often selected; thus warehouses have been shown to be built for bulky, light-weight merchandise to vary 20 per cent in size only because of different arrangement of the storage space and facilities. Uneconomical design and detail are quite often selected. The author quotes cases where the steel frame of a building was so designed that sorting the framing was like taking jackstraws out of a pot. He claims to have known a case where 8 per cent was saved in the total cost of a simple factory building by leaving out a useless line in the brickwork and changing very moderately the spacing of columns.

In architects' offices the working out of details of plans and specifications is delegated to men who are only theoretically trained, with the result that extravagant arrangements are sometimes prescribed.

A further cause of waste is due to the usual inflexibility of contracts which prevents making desirable changes after the work has started. Poor timing and coordination of the various trades is likewise apt to increase interest charges and hence the cost of building, while the business relationship between owner, architect, and contractor, particularly the former and the latter, tend toward the employment by the general contractor of incompetent sub-contractors.

To combat this natural result of an unsound procedure, another wasteful procedure is commonly invoked. The architect or engineer places on the job an inspector whose duty it is to see that there is delivered the quality of materials and workmanship called for in the specifications.

Theoretically, a real representative of the designer, permitted to cooperate fully with the general contractor and the sub-contractors, would see that advantage is taken of new and unforeseen conditions; that ideas for simplification and improvement of the work are submitted promptly to the architect and, through him, to the owner; that there shall be minimum delay in making decisions and in carrying them into effect—all to the end of an efficient economical job. Most men, progressive and successful in business, will acknowledge that in their own field such cooperative coordinated effort is a prerequisite today to success.

In their building problems, however, it is a strange fact that these same men still cling to a system that from the start sets up an opposition of interest to their own, discourages if it does not preclude cooperation, and puts themselves on the defensive, protected only by specifications based on imagined conditions and by an inspector stripped of all power except that of rejection. It would be quite as logical, it seems to the author, to buy surgical operations on this same basis of price and inspection. Cheap price does not necessarily mean high value, and inspection is no substitute for honesty and ability; yet heaven only knows how much money is annually spent and wasted under this unsatisfactory system.

Some architects in New York City have recognized all these factors and are finding a way to combat the resulting losses.—*Contract Record and Engineering Review*, vol. 43, no. 31, July 31, 1929, pp. 899–901.

[5] Recent failures of galvanized, heat-treated wires in the cables of a suspension bridge have raised the question whether strength of metals exposed to corroding agencies may not diminish with time.

The Fundamentals of Management Applied to Industrial Enterprises

By L. P. ALFORD,[1] NEW YORK, N. Y.

SHARP differences of opinion exist in regard to management engineering, or industrial engineering, both among practicing engineers and engineering educators. There are those who do not believe that a sufficient body of fundamentals and practice has been developed to warrant the inclusion of this newest branch of engineering with those which are older and have had a more extensive period of development. Others there are who maintain that both the principles and practice of industrial engineering have been organized to a sufficient degree to permit of regarding management as an established branch of engineering. Today we are to consider only the teaching aspects.

Whatever may be one's point of view, there are many clear-cut statements in the official publication of the Society for the Promotion of Engineering Education in support of industrial engineering. The report of the Committee on Industrial Engineering for 1928 declares: "The Committee believes that the necessity does exist for a course in industrial engineering." Dean Sackett in his presidential address of last year wrote: "The growth of a sound economic or industrial philosophy is of increasing value to the engineer as well as to the citizen. Again, it is not the addition to a crowded curriculum that is necessary to balance the educational budget but a better understanding by engineering teachers of the elements of a healthy industrial doctrine. When we have it, then it should be woven into the fabric of engineering training."

Attitude Toward Subject

In Bulletin No. 13 of the Investigations of Engineering Education it is shown that 45 per cent of the engineers who replied to a questionnaire in regard to courses, advocated the teaching of industrial management "for inclusion in all engineering curriculums." Only 17 per cent of the teachers of engineering considered this subject "of primary importance." These percentages may be somewhat indicative of the attitude toward the subject.

Turning again to recent reports and declarations of this Society, major emphasis is placed on fundamentals. In Bulletin No. 13, previously referred to, is this statement: "Many of the engineers add comments to the effect that the curriculum should be devoted to fundamentals chiefly." And, again, in President Sackett's address: "We have not yet developed the essential factors of management in a form acceptable for certain teaching purposes. For the industrial engineer there is a promising body of knowledge in form for his instruction and for his professional uses. No other class has been more alert in sifting and selecting principles and practices of value to the human element in industry."

In spite of the differences in point of view, there is a sufficient support both for the course in industrial management on the one hand, and for the necessity of formulating the principles thereof on the other, which warrants an attempt to show that these fundamentals exist, whence they have arisen, their nature, and examples of what they are.

Since the business depression of 1922 there has been a tremendous development of the economic function of management. The Hoover report on "Recent Economic Changes" declares that this progress is one of the chief reasons for the remarkable prosperity of the United States during the past seven years. And, further, that it is one of the major avenues through which trained intelligence has been applied to the every-day problems of business and industry.

During this period attempts have been made to organize both the practice of management and its fundamentals. The recognition accorded these attempts indicates on the one hand the demand for management information organized in such a way, and, on the other, the fact that the practice of management has been carried far enough to develop accepted methods and procedure based on a common foundation of principles.

During the seven-year period referred to, some half-dozen college textbooks on industrial management have been published. A scrutiny of them will show that in every case an attempt has been made to formulate and declare principles in a form in which they can be taught. These efforts are very evidently in line with the declarations made to this Society. Prof. H. P. Hammond in the September, 1928, issue of the *Journal* of *Engineering Education*, suggests as two of the aims in developing teaching methods:

> In a given field to determine what elements of theory and practice are of primary and of secondary importance, and having established the essential core of principles, to study its organization into a structural whole
>
> To learn something of the history of the subject—its origins and evolution—in order to provide a background from which to teach it.

Confused Situation Produced

From the very outset of the development of industrial management, attempts have been made to draw forth and present underlying principles. Frederick W. Taylor reduced his principles to four statements. Harrington Emerson declared his "twelve principles of efficiency." The writings of Henry L. Gantt are filled with references to the principles involved. Thus from the start the necessity of recognizing fundamentals in management has been in the forefront of the minds of the leaders of the movement. But no uniformity of thought is shown by the work of these pioneers, and, seemingly, their writings taken together produce a situation of confusion.

Possibly one reason for this confusion is the failure to investigate the origin and nature of management fundamentals. Seemingly there are three ways in which they can be observed: from a psychological basis; as a direct branching off from the main stem of applied science as practiced in engineering; and as a result of the process of societal evolution.

The psychological basis seems unsatisfactory, for management is dealing with functions and practices far broader in scope and application than the reactions and behavior of human beings as individuals.

The branching off of management engineering from the main stem of applied science has not as yet been adequately explored. Seemingly the point of union is at the second law of thermodynamics. Management seeks to control chaotic forces, endeavors to organize the factors employed in doing work, for organization is the antithesis of chance, or, as Eddington[2] calls it, "the random element."

[1] Vice-President, The Ronald Press Co. Mem. A.S.M.E.

A lecture delivered at the S.P.E.E. Summer School for Mechanical Engineering Teachers, Purdue University, June 27 to July 18, 1929.

[2] "The Nature of the Physical World," p. 75.

A practical measure of this random element, which can increase but can never decrease, is called entropy. Eddington says of it: "I wish I could convey to you the amazing power of this conception of entropy in scientific research. From the property that entropy must always increase, practical methods of measuring it have been found. The chain of deductions from this simple law have been almost illimitable; and it has been equally successful in connection with the most recondite problems of theoretical physics and the practical tasks of the engineer. Its special feature is that the conclusions are independent of the nature of the microscopical processes that are going on. It is not concerned with the nature of the individual; it is interested in him only as a component of a crowd."

Lotka[3] holds the same point of view: "We at once recognize also that the law of evolution is the law of irreversible transformations; that the direction of evolution (which has baffled description or definition in ordinary biological terms) is the direction of irreversible transformations. And this direction the physicist can define or describe in exact terms. For an isolated system, it is the direction of increasing entropy. The law of evolution is, in this sense, the second law of thermodynamics."

The third point of view, that is, that management has risen through societal evolution, seems more satisfying and is supported by abundant facts. Historically we know that the ancient peoples in doing work tried many of the methods which are accepted in good management practice today. Such are—division of labor; specialization of labor; transfer of skill; stores control; incentive wage payment; and the definite task. Further, fully two centuries ago there were examples in British industry of standard practice instructions; materials specifications; time-keeping; material budgeting; costing; and industrial welfare.

A study of these methods and processes leads to the conclusion that they were developed as society developed, and as the necessity arose to plan and carry forward the doing of work. Seemingly this background, which stretches some four thousand years into the past, should give us greater confidence in the methods of management and the fundamentals upon which they are based.

Turning now to management fundamentals as applied to industrial enterprises, and as revealed by a study of accepted ways of doing work, three characteristics seem to emerge. Management fundamentals are:

Resistive to change
Universal in application
Imperative to highest success.

It must be admitted that there is as yet no uniformity in the language in which they are stated, although for many of them a similarity or identity of concept can be discovered. In this respect, however, there is little difference between this situation and that which prevails in other branches of engineering. For example, it would be comparatively easy to list half a dozen different statements of the second law of thermodynamics previously referred to.

GROUPING OF FUNDAMENTALS

The nature of the methods and work of management is such that it is possible to develop a grouping of the fundamentals along the lines of their application. One such grouping is:

Leadership
Executive Work
Specialization and Standardization
Production Management
Individual Productivity
Wage Payment
Safety and Maintenance
Manufacturing Economy.

As to the kind, these fundamentals in general group under but two heads: Those which, as formulated, show relationship between cause and effect, and others which indicate an established trend. It is thus seen that they are on the order of the so-called "statistical laws" rather than having the characteristics of the principles of mathematics, physics, or chemistry. It is probable that this difference deserves careful consideration when these management fundamentals are being arranged and organized for teaching purposes. When the engineering student is first introduced to them he might be made to see in what way they differ from the other laws with which he is so familiar, that he may grasp their importance, and readily learn how to make them a part of his own thinking and to apply them later on in his own work.

INSUFFICIENT ATTENTION TO FUNDAMENTALS

Inasmuch as these fundamentals show on the one hand cause and result, and on the other established trends, it is evident that they do not lend themselves to experimental demonstration, nor to showing their application by an experimental method. However, their limitations can be explored and their factors determined by experience. Unfortunately not enough attention has been given to this matter, so that we lack a satisfactory knowledge of limitations and experiential factors.

By way of example there now follow the principles of specialization which are a management adaptation of the familiar economic law of "division of labor."

Division of Work or Specialization of the Job:
Subdividing work so that one or a very few manual or mental operations can be assigned to a worker improves the quality and increases the quantity of output.

Division of Effort or Specialization of the Individual:
Assigning to each worker one or a very few manual or mental operations which he is particularly adapted to perform improves the quality and increases the quantity of output.

Corollary: Function Management (Function Foremanship) or Specialization of the Management:
As the scope of an executive's responsibility is narrowed his efficiency increases.

Transfer of Skill or Specialization of Tools and Machines:
The attention and skill required to use a tool or operate a machine is inversely as the skill transferred into its mechanism.

Simplification or Specialization of Product:
Concentrating upon the manufacture of a single or a few types and sizes of product tends to improve the quality and lower the production cost.

The first two are unusually comprehended in the principle of division of labor, although it is quite evident that the job or work can be subdivided without assigning an individual to any of the sub-operations separated out. That is, the operation of subdividing the job can be, and usually is, independent of the individual worker who is to undertake any part of the subdivided work. And the subdivision can be assigned to one individual or another at will.

The division of effort and specialization of the individual is rather close to the economic concept of the division of labor, but it does not comprehend the corollary which was so strongly emphasized by Frederick W. Taylor in his management practice.

The principle of transfer of skill, though recognized by the ancients, has had emphasis in industry only within the past quarter of a century. Without doubt it is the fundamental above all others that has contributed to the upbuilding of our machine age.

[3] "Elements of Physical Biology," p. 26.

The principle of simplification and specialization of product can be traced back something over a century. Its practice was first developed by two pioneer American manufacturers, Simeon North and Eli Whitney.

Another group of fundamentals, which can profitably be given as an example, includes the principles of productivity as formulated by Past-President Kimball of this Society. They are observed to be a management formulation of the economic law of diminishing returns, but stated in a form to apply to industrial production.

"*a* The law of increasing productivity, which may be expressed as follows:

> The unit cost can, in general, be decreased as the quantity to be produced increases
>
> This follows naturally from the general condition that as quantity is increased greater advantage can be taken of time-saving machinery and division of labor.

"*b* Productive effort usually depends upon the use of several coordinate facilities.

> In general it is not possible to operate all of the facilities at a high degree of efficiency, but a limited number can be so operated if the others are permitted to operate at a comparatively lower rate of efficiency.

"*c* The law of decreasing productivity may be expressed as follows:

> Every economic gain is, apparently, accompanied by a corresponding economic loss which tends constantly to neutralize the effect of the economic gain."

Other examples of principles of management are easily discovered in the literature of this branch of engineering, although it may be that they have not yet been adequately organized for teaching purposes. This point of view is supported by the presidential statement of Dean Sackett already quoted. In the literature to which he refers can be found numerous applications of management principles. In many cases the economic result from application is also stated. For instance, production control if applied according to the best principles and practice should, on the one hand, increase production from 100 to 300 per cent and, on the other, insure the shipment of orders in from 85 to 95 per cent of all cases.

Up to this point this discussion has dealt primarily with management fundamentals as applied to manufacturing or the production process. Once these principles have been formulated in language that takes them away from the shop setting, it is readily seen that they apply to any human activity concerned with the doing of work. Thus they have been successfully employed in organizing and operating financial institutions, distributing agencies, service institutions, and the household. Seemingly, the characteristic of "universal in application" is as broad as the doing of work by human beings.

In view of the declaration that flows so strongly through the literature of this Society that engineering students should be taught fundamentals, it would seem, to one who is not a teacher, that a starting point in management instruction is the development of the essential factors or principles in a form to be taught. In their presentation might be included a bit of cultural training, for their roots lead back to the activities and work of ancient peoples to a greater degree than is true of any other branch of engineering.

Uniform Safety Codes Needed

BY C. B. AUEL,[1] EAST PITTSBURGH, PA.

ACCIDENT prevention is not the simple problem originally thought to be confined to mechanical safeguarding of tools and equipment as the single solution, but is most complex. There are several partial solutions, all of them important, which include the guarding of tools and equipment, health, education, and supervision.

Guarding of tools and equipment is relatively the least important, and in those concerns where study has been given to the problem of safety, such guarding has been carried about as far as it is at present possible. Accidents, however, continue, and without going back to first causes may now be said to be due largely to or the result of flying particles and the dropping of material.

To overcome this type of accident safety engineers are recommending, aside from the wearing of safety shoes, the substitution of mechanical devices for the human element such as cranes, hoists, lifts, chutes, battery trucks, automatic feeds, conveyors of all kinds, and industrial railways.

It was the users of machinery who first called the attention of designers and builders to the necessity of better safeguarding their products, and unfortunately they still find it necessary at times to do so.

Builders of machinery are many times willing to offer their products without guards in order to lower prices, leaving the guarding to be done by the purchasers.

It is not fair nor is it economy to put this problem up to the purchasers as it makes each customer solve the same problem instead of solving it once and for all. The smaller user probably cannot solve the problem at all, and must in due course pay the price by having accidents, while large users may solve the problem more or less completely at various costs and in different ways—always a source of danger in itself as some of these solutions may introduce other hazards. Guards should be designed by the tool builder.

Attention should be directed to the safety codes of the various states, and to the desirability of having uniformity among them, which is not at present the case. An economic waste of no small magnitude is being inflicted on manufacturers and users alike when individual state codes are developed instead of having a national code for each subject. Each manufacturer and many users must constantly refer to every code of every state to keep abreast of requirements. Furthermore frequent changes, for these codes are revised frequently, have a tendency to substitute one hazard for another.

An appeal is directed to the schools and colleges to teach safety, to manufacturers of equipment to guard their equipment thoroughly, and to the states to adopt uniform safety codes. The states should have universal health examination of all young scholars in public, private, and parochial schools at periodic intervals with a subsequent follow-up on the part of parents. Industries cannot take sub-normal workers, and all too many of the younger generation are such, and turn them into normal beings functioning as they should.

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[1] Manager, Employees Service Dept., Westinghouse Electric and Mfg. Co. Mem. A.S.M.E.

Abstract of paper presented at the Materials Handling Session of the Rochester Meeting, Rochester, N. Y., May 13 to 16, 1929, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

Some Fundamental Principles of Materials Handling

Their Effect Upon Industrial Plants and Economic Production

By HAROLD VINTON COES,[1] NEW YORK, N. Y.

IN THE past decade the United States has passed from the position where its industrial capacity was taxed to produce the things which it consumed annually within its own confines to the position where it can produce in approximately nine months all that it can consume in twelve, where the former roles of buyer and seller have been reversed, and where it is now necessary to resort to instalment buying and the extension of export business in order to maintain production at the present high levels.

Such phrases as "profitless prosperity" have crept into business literature. Those engaged in professional business surveys, examinations, and operations know the term and the reality only too well. It implies production at high levels with inadequate returns or no return for the efforts put forth—trading dollars. It means overproduction for the present available markets and too high production and distribution costs to compete successfully in the available markets against the plants producing at low cost. Consequently the problems of lowering the present costs of production are becoming continually pressing and are having focused on them more and more executive and professional attention. We are only concerned in this discussion with that phase of reduction of production costs that can be brought about by the reduction or elimination of those high costs due to materials handling.

Law of Price

It can be taken as axiomatic that no industry can long continue to exist on a price basis alone, that is, without adequate profits.

There is an economic law that the price of any given commodity tends to approach its cost of production, but it should be noted that cost of production as used in this law includes all legitimate costs of extracting, processing, production, and distribution, and a reasonable profit as well.

Profitless Prosperity

Profitless prosperity is not confined to any one industry or section, but is entirely too prevalent in many industries and sections today. It violates the economic law mentioned above, and is now engaging the attention of some of the keenest minds in the country in all lines of business.

Effect of Immigration Laws on Materials Handling

The United States has, in effect, by virtue of its selective immigration laws, a protective tariff on labor. The effect of this on wages can be visualized to some extent from the U. S. Census of Manufacturing reports.

Census year	Average wages per wage earner per census year, dollars
1899	426
1904	487
1909	530
1914	590
1919	1163
1921	1181
1923	1254
1925	1280

Now it is one thing to pay $426 per year for human labor to push, haul, and otherwise manually transport or move materials, and quite another thing to pay three times this amount. Therefore, restrictive immigration has forced the consideration of practical ways and means of mechanizing the operations, particularly in materials handling, still performed by hand labor.

For example, it has been definitely established[2] that the average sustained walking speed of a man pushing a hand truck with an average load is approximately one-tenth of a mile per hour, while the average running speed of a fully loaded electric industrial truck is seldom less than four miles per hour. The average load of the ordinary hand truck is not over a few hundred pounds, while the average power industrial truck carries from two to three tons. Therefore the work done by a man with a power truck is from two to thirty-five times that of a man with a hand truck, depending upon the industry and the type of service, but a conservative figure would place this factor at five as a general average.

Cost of Handling Materials

A survey made for a leading trade paper in this country a year or two ago revealed that the estimated materials-handling labor cost to American industry was 22 per cent of the total annual payroll of American manufacturing industries. In 1923 this represented $3,084,000,000 of the $14,017,107,000 payroll for that year.

Eugene B. Clark estimates that manufacturers in this country pay for moving materials within their plants 80 per cent of what they pay for freight, express, and parcel post.

The real difficulty about materials-handling costs is that they usually are not segregated or known. They are generally buried in the burden or manufacturing expense. In plants, however, where a careful study has been made of operations and the handling of materials in detail, the insidiousness of the situation has been revealed and it has been found that a large proportion of the productive worker's time was being utilized in non-productive operations of which materials handling was an important element. The cost of production of most products is almost directly proportional to the cost of handling the various materials, direct and indirect, used in the process, whether in their extraction, manufacture, or erection.

Material, in traveling through the processing route, is worked on (i.e., direct-labor operations), it is estimated, on the average of only from 30 to 40 per cent of the possible time and quite frequently only 15 to 20 per cent of the time.

The productive worker's time may be entirely charged to the direct-labor account, yet a close study of his activities reveals that by moving or going after stock, tools, jigs, or fixtures, waiting for material to be delivered to him or taken from him, he is actually working only one-third to one-half the time on productive operations.

Many times a careful investigation reveals that a plant is actually expending by way of the indirect payroll (frequently buried in the burden of factory overhead expense) an annual amount which if eliminated by mechanical handling would pay for the necessary materials-handling equipment in from one to two years.

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A lecture delivered at the S.P.E.E. Summer School for Mechanical Engineering Teachers, Purdue University, June 27 to July 18, 1929.

[2] Society for Electrical Development, Inc.

NEW-PLANT OPERATION

In a new industrial undertaking, materials handling is an important factor in determining—

a The plant location and site
b The plant layout, present, and for future expansion
c The departmental layouts, relationships, and interplant arrangements
d The production equipment, sequence of operations, and layouts
e The operating cost per unit of product.

Obviously, for a minimum investment and low cost of operation, the new plant should be so located, designed, and equipped as to take full advantage of all the favorable, natural, and economic factors. The materials-handling methods and devices should be sufficiently worked out at the time the plant is designed so as to make them an integral part of the design and of the future operations.

An individual plant is not a receptacle into which one can throw money, men, materials, machinery, and methods, shake them up and precipitate satisfactorily low-cost finished products. Why, therefore, perpetually handicap the business by embodying in unyielding bricks, mortar, steel, and concrete at the outset, conditions which make it economically impossible properly and adequately to install and operate materials-handling equipment? Yet this is being done entirely too frequently. It requires brains, knowledge, experience, and skill to properly design, build, equip, and operate an industrial plant.

EXISTING PLANTS

In an existing plant the proper selection, installation, and coordination of adequate materials-handling equipment will, as a rule—

a Increase the output
b Lower the costs of production
c Smooth out the production flow
d Release working capital by decreasing the manufacturing cycle, thereby reducing process inventories
e Speed up deliveries
f Facilitate management and administration.

FUNDAMENTAL PRINCIPLES

1 Lay out the processing sequence of operations and route. Reduce the lines of travel to the minimum. Coordinate the flow of minor and sub-assemblies.

This definitely locates the aisles, doors, elevators, stairways, per building. It further determines the location of the receiving points and stock room, process and finished stock rooms, in and out railroad spurs, roads, etc., subject, of course, to the confines and physical limitations of the property.

2 Every element of materials-handling equipment should be selected not only to perform the work at present but, in most instances and except in specifically isolated cases, to fit into the program conceived for the ultimate plant or for the rehabilitation of the existing plant.

3 Eliminate all unnecessary handling operations; perform all necessary handling operations by gravity wherever economically possible, then consider power operation.

This statement seems almost axiomatic, yet it is no uncommon thing to go into a plant and see laborers performing operations that are absolutely unnecessary, many of which could be eliminated at a very moderate expense, and some of which could be eliminated by the application of brains and planning alone.

4 Choose the methods and equipment for performing the necessary handling operations that will result in the lowest cost.

It often happens that the first solution of the problem does not result in the lowest cost when compared with subsequent solutions. It is therefore decidedly advisable to compare the cost per unit handled from several practical methods of solving the problem, and then select the methods and equipment which will result in the lowest cost.

5 Choose standard, proved, and tried equipment wherever possible.

Few businesses can afford to divert the efforts of the organization or the facilities of the plant to experimenting to produce a new materials-handling device unless the products and the processes or the intermediate operations are such as to render it advisable or necessary to design devices to suit conditions that equipment now on the market cannot successfully meet. Otherwise it is decidedly better to endeavor to solve the problem with existing facilities.

Tried and proved materials-handling equipment produced by reliable manufacturers is just as dependable in performance and in freedom from breakdown, and usually just as economical in operation and maintenance, as the production equipment proper; charges to the contrary cannot be generally sustained. If breakdowns occur and if maintenance is high, it is more usually due to a lack of care, to improper selection of the units in the first place, and to overloading the equipment beyond its designed capacity.

One cause of much subsequent economic woe in the selection of materials-handling equipment for a specific set of conditions is the confusion between service and mere mechanical or electrical performance. A piece of equipment may be mechanically perfect and yet its selection for a given set of conditions may be economically unsound if it has not been designed to function so as to meet all of the conditions imposed, and therefore must operate at a loss.

Selection of materials-handling equipment should be predicated on the following data:

a The nature of the commodity or commodities to be handled
b The size, shape, weight, relative fragility, etc.
c Amount to be handled per hour, per day, etc., in (*a*) pieces, (*b*) pounds, (*c*) tons, or (*d*) units
d Distance the parts or commodities are to be moved horizontally or vertically, or both
e Type of container, skid, rack, etc., on which parts of the commodity are received at the point of translation
f Standardization of factors in item *e*
g The number of times the part or commodity is now being handled
h The effect of speed of translation on the article or articles to be handled
i Production rate of the equipment at the originating point of translation
j Sequence of manufacturing operations
k Interplant and department relationships
l Location of raw, process, and finished stock rooms
m Location of incoming and outgoing railroad spurs, roads, etc.
n Cost of unskilled common labor.

6 The materials-handling devices and equipment for a new plant should, for lowest investment costs, be an integral part of the plant.

In designing a new plant and selecting a site for one, use every natural advantage that can be called to aid, either in eliminating the amount of material that has to be handled or the length of the travel, horizontally or vertically. Frequently, gravity can be made to do a large portion of the work, in which case slides, chutes, rollways, spirals, and the like can usually be made an integral part of the structure.

7 Provide for flexibility so that the failure of any one of the materials-handling devices or equipment will not shut down the plant.

8 The path of the material should be as direct as possible from the receiving point through the processing steps without rehandling and with the minimum retrogressions in the whole line of travel.

Before arranging for any system of shop or plant transportation, a study should be made to see if the departments can be arranged so as to permit minimum travel in logical sequence with the minimum of retrogressive movements. In other words, materials should not be transported any further than is absolutely necessary. Frequently, a study of the departments, their relationships, and the sequence of operations or processes will reveal that a rearrangement can be made to advantage.

9 Investment must be justified by the return.

It stands to reason that the return on the investment should be such as to justify the original investment, yet this principle is frequently violated. Many of the progressive companies have a fixed policy that provides for the scrapping of any piece of equipment or process whenever it can be shown that the proposed piece of equipment or process can earn 20 to 25 per cent, in other words, the investment amortized in from four to five years. Obviously, this is good business.

10 Return should provide for adequate fixed charges.

In order to show the proper return on the investment, provision should be made in calculating fixed charges, for interest, taxes, depreciation, insurance, obsolescence, etc.

The foregoing principles can be summarized by the three which follow:

a In handling any material, perform only those handling operations that are absolutely necessary
b Perform these operations in the manner that procures the least cost
c No single piece of equipment, as a rule, is capable of being adapted to the solution of all the materials-handling problems in a given situation.

Is Return on Investment Justified?

There are many intangible benefits that frequently accrue from the correct solution of materials-handling problems and shop-transportation problems besides the direct saving in labor, even though the installation of the materials-handling equipment may be justified for this reason alone. These other benefits are as follows:

1 Reduced production space, permitting increased production without increase in space requirements
2 Lowering the cycle of goods in process
3 Reduction of process inventories
4 Steadying of production and enhancing the control, resulting in better deliveries and increased sales
5 Speeding up of labor, since machines and men are not kept waiting for materials
6 Better cost and production records.

Norman H. Preble, later referred to, states these reasons in the following manner:

In general, any one of three reasons may justify the installation of materials-handling equipment:

1 The actual saving to be effected through the cutting of materials-handling costs
2 The possibility of increasing or speeding up production without adding to plant or floor space
3 The necessity of relief from chaotic conditions in the plant due to lack of an adequate system of handling or storing supplies or materials in process.

In many modern plants, actual productive operations are performed while the manufactured product or unit is in motion, thus completely saving a great amount of non-productive handling. In the automotive field, this method is used extensively. In many other industries, such as the manufacture of stoves and ranges, gasoline pumps, refrigerators, pianos, furniture, heavy electrical apparatus, machine tools, washing machines, vacuum cleaners, typewriters, adding machines, etc., the product itself is moved by conveyor from workman to workman, from operation to operation. This method of manufacture is applicable to many fields in which it is not now employed.

Obviously, if the plant is designed initially to provide for this type of manufacture and assembly, production costs will be materially decreased.

Rules for Securing Materials-Handling Economies

R. H. McLain of the General Electric Company sets up the following rough guide points where economies, by the use of machinery instead of men, may be looked for where the men are unaided by any mechanical device:

1 Where three or four men are working together on one job for a couple of hours at a time, even though the work is not performed more than three or four times a week
2 Whenever a man has to lift anything from his feet to a point above his head
3 Whenever a man has to lift more than 50 lb. from his feet to his shoulder
4 Whenever a man has to lift more than 100 lb. from his feet to his waist
5 Whenever a man has to lift more than 150 lb. from his feet to his knees
6 Whenever a man has to stand in one place steadily moving material for more than 30 minutes
7 Whenever a man has to move material sideways more than six feet, that is, approximately two steps
8 Whenever a man or group of men, although moving around in a small radius, have to move more than ten tons of material per hour.

Norman H. Preble, of the Mechanical Handling Systems, Inc., Detroit, in his book "Conveyor Facts," lists a few cases where handling expense can be reduced as follows:

1 Where unnecessary handling is performed
2 Where more than one man is moving material without labor-saving devices
3 Where men are lifting and handling articles weighing more than 100 lb., or bulky or awkward articles
4 Where men are loading from floor to trucks or from trucks to floor
5 Where machine operators are doing any laborious lifting or any work, except putting an article into the machines, supervising the machinery operations, and removing the articles, when finished; to allow lifting and carrying by machine operators is to indulge in a most expensive luxury
6 In the moving of material from container to container
7 Where men on assembly floors or elsewhere are looking for or waiting for material
8 Where losses exist due to damage or breakage in handling of fragile or highly polished goods.

Source of Materials-Handling Losses

Losses directly attributable to materials handling can originate from the following sources:

1 Unnecessary handling of materials
2 Excessive direct or indirect labor
3 Uneconomic plant layout
4 Defective system of manufacture, resulting in the wrong sequence of operations
5 Bad design of product to be manufactured, involving excessive handling
6 Inadequate or improper materials-handling equipment
7 Poor scheduling.

The materials-handling formula of The American Society of Mechanical Engineers furnishes a ready means of comparing alternative processes, methods, equipment, etc., and will aid in establishing the measure of these losses and the savings to be effected by suitable equipment.

WHAT WILL MATERIALS-HANDLING PROGRAMS ACCOMPLISH?

Properly selected and installed handling equipment will—

1 Permit transferring to the capital account of that portion of the overhead that is composed of indirect labor in the operations
2 Reduce the manufacturing cycle
3 Reduce the process inventory
4 Speed up, coordinate, and stabilize production
5 Facilitate the obtaining of accounting and production data
6 Substitute automatic mechanical scheduling for the former complicated and expensive scheduling and production systems
7 Govern the layout of the new plant and improve the performance in existing plants
8 Facilitate deliveries.

In Volume 1 of "Recent Economic Changes" as issued by the National Bureau of Economic Research, a table appears (pp. 140–141) setting up fifty typical installations of materials-handling equipment; comment on this table is as follows:

The lessening of the supply of crude laborers, owing to the restriction of immigration, reduction of working hours in certain industries, and the greatly increased cost of unskilled labor have compelled the installation of machinery and equipment to do work formerly performed by muscular effort. Two beneficial results have been secured:

1 A reduction in the cost of moving and transporting material and product.

2 An increase in production for the new machinery, in many cases, has set the pace of the production process.

The table gives information on fifty typical installations of materials-handling equipment. For each item, the material or product handled is indicated, the kind of machinery installed is designated, the plant where the installation was made is named, and the savings or improvements are given. For thirty-seven of these installations the savings aggregate more than $850,000 per annum. For many of these, and for most of the other thirteen, the statement is made that production has increased:

"The control of production which is being secured through the aid of modern materials-handling machinery is probably the greatest single improvement which has come in the technical operation of manufacturing establishments since 1919."

Engineering and the Human Values

THE title which stands at the head of this article is that of an address[1] which Ralph E. Flanders, manager of the Jones and Lamson Machine Company, Springfield, Vt., delivered a few months ago to a group of engineers and students in Knoxville. "Is human life," he asked, "in any sense deeper and richer for our (engineers') dominant influence upon it? Can we make contributions to it of our own peculiar kind that will deepen and enrich its future course?" After asserting that such questionings were not natural to the engineering student, he said that it was not so with older men.

He made his case well and eloquently, neither minimizing the bad effects of engineering upon our environment nor exaggerating the countervailing good which it had wrought. But one cannot but feel that in many cases the good is primarily only good because it corrects the evil which the engineers themselves have effected. Consider, for example, such matters as the cleansing of the atmosphere or of rivers. If the engineer had not already vitiated the air and the water, the need for purification would not exist. Or to take another striking example from Mr. Flanders, had cement factories never been established, the prevention of the dust nuisance by wet grinding would never have been called for. We submit that this is an important aspect of the problem, one upon which the eye of the engineers of the future must be kept closely fixed. The murmuring to which Mr. Flanders referred will grow in volume, the protests against the obviously objectionable features of engineering will become louder and louder, and the benefits which the works of the engineer confer will be overshadowed by the nuisances that accompany them, unless engineers themselves are the first to recognize the defects and the first and the most eager to remove them. We must not say, "If you want railways and motor cars, you must put up with their noise; if you want steel and coal, you must sacrifice a whole countryside to filth and ugliness; if you want cheap electricity, you must poison with ashes and sulphur the air of your cities." That was the attitude of the past; it will be intolerable in the near future. We must have the products, which the engineer and the engineer alone can give, but they must be so purified from all offense that they can live side by side with less material, but perhaps not less important cravings of civilized people. The "human" must be set against "the money value." We must use Mr. Flanders' terms, and if they cannot be made to balance, then the human must be allowed, even be encouraged, to prevail. Mr. Flanders endeavored to convince young engineers that the effects of engineering are not so bad as they are painted by artists, moralists, literary men, and philosophers. It is of equal importance that the coming engineers should have the defects ever before them, and that they should be taught that the greatest aim that they can have is so to discharge all offense from engineering that not the keenest critic can find a word to say against it.

To the engineer all things are possible. He can give a pure atmosphere and noiseless streets, he can remove slums and make wholesome factories, he can wipe away degrading occupations and improve the occupations of leisure, he can make a fair country out of a blasted waste, and clean rivers out of foul ditches. All these things, and a thousand more, he can do without robbing us of a single one of the benefits and advantages which his works confer. We say this with confidence, because we witness daily all he has achieved. But a vast amount remains to be done, a mountain of ugliness remains to be removed, and we deem it a good thing that the coming generation of engineers should grow up in the belief that it is the duty of engineers to make the countries in which they live more beautiful and more pleasant and wholly free from the taunts which artists, literary men, and philosophers may justly throw at them today.—*The Engineer*, London, August 2, 1929, p. 122.

[1] See MECHANICAL ENGINEERING, September, 1929, p. 649, for the text of this address.

Present Status of Engineering Research[1]

By CONRAD MATSCHOSS,[2] BERLIN, GERMANY

A CONSIDERATION of technical-scientific research shows that the fundamental sciences may justifiably demand the utmost respect; they are the source from which new fundamental knowledge is constantly springing.

It may be generally stated that it is a characteristic of modern scientific research that learned men attempt to trace the complicated forms that recur so frequently in the design of machines and in technical equipment to the simplest natural laws. To these belong the study of heat radiation of hot gases and refractory bricks, of the heat conduction of metals at high temperatures, and tests of the combustion and ignition process in engines. The work of the Physico-Technical State Institute in the study of heat transfer in superheated and saturated steam has brought definite clearness especially with regard to low pressures. The same tests are to be made with high-pressure steam for the purpose of determining the physical properties of high-pressure steam. The laboratory of the Munich Institute of Technology has done valuable work in this field.

The researches on the flow of fluids carried on principally in the experimental institute of the University of Göttingen are noteworthy. This is a goal to be reached only through the widespread application of all mathematical and physical research methods. In this connection attention should be called to the work on measurement of flow undertaken by independent research as well as by the industry, since in this connection the committee on flow research of the V.D.I., together with a professional committee of The American Society of Mechanical Engineers, will develop a standard measure or a standard nozzle with a coefficient of flow as constant as possible at various Reynolds figures.

The V.D.I. committee on vibrations is especially interested in those processes which may be used to measure and test materials and which have proved themselves superior. In a similar manner research on building foundations has been executed. The work done by the German Society of Structural Engineers, together with that of the V.D.I., to ascertain the influence of wind on structures, has been extended to tests on exposed buildings.

The study of the strength of materials has led to numerous tests with alloys and to the introduction of materials which up to now have been rarely used. Of the non-ferrous metals in which research is at the present time most interested are copper and aluminum alloys. The question of fundamental importance seems to be how the treatment of aluminum alloys, amenable to treatment (duralumin, lautal, aeron, etc.), may be explained and conquered and what influence the treatment may have upon the strength properties of these metals. The behavior of aluminum alloys which may be treated at low temperatures is receiving increasing attention from experts. In contrast to former times, in addition to the so-called rolled alloys, aluminum-alloy castings are receiving more and more consideration. In the realm of copper alloys, now as well as formerly, attempts are under way to replace the costly bronze alloys with cheaper special brass. Tests on the wear, corrosion, and machinability of special brass as compared to those of bronze are under way, but unfortunately their number is small.

Among the non-metallic structural and engineering materials, wood is receiving especial attention and is proving itself adaptable to manifold purposes.

In its "Lehrschau Holz" (Wood Exhibition) the V.D.I. on the occasion of its chief meeting in Königsberg will attempt to make all that is worth knowing in this field visible.

The training of engineers and of all those actively engaged in industry must not be neglected while we are engaged in spreading all available knowledge. It is not a question of making money; even if the German machine industry had really acquired this art, we engineers should not consider economic results the goal of our life's work nor the true significance of engineering. To realize the cultural significance of this work, the history of engineering must be correctly understood. Obviously it cannot consist of merely stating new facts constantly nor in adding to those already known, but must, above all, point out the development of engineering and the meaning of the work done by great men. The history of great engineers can create a fountain of youth from which new joy and enthusiasm for the great work in engineering may spring again and again. The flame of enthusiasm for lofty aims must be kept alive from generation to generation.

In addition to what may be learned from the history of engineering, and what seems most important today, is the arbitrary dependence upon one another of the various classes of people engaged in technical work. It would also signify an unusually great cultural as well as economic advantage if it were possible to leave the political struggles of the day in order to arrive at unity and thus to demonstrate that work everywhere is once more becoming the greatest incentive that life has to offer.

Advance in Testing and in Choice of Materials

In recent times great progress has been made in the technique of welding, especially in the knowledge of influences which may become determinative concerning the strength properties of welding. The methods of practical testing of materials, such as X-ray research, boundary surface forces, microanalytical processes, etc., find widespread application. The X-ray analysis of material to determine inclusions, blowholes, etc., has proved itself very practicable. The development of a process for testing the grain structure of metals is now also attracting attention. In the realm of welding technique this test is of outstanding significance as, through it, strength properties may be determined without causing the destruction of the weld. Observations have been made by means of moving pictures which show the actual processes step by step of the flow of materials in the welding arc; from this, conclusions on the strength of the weld could be drawn. This progress in scientific knowledge brings about a constantly increasing use of welding in the construction of buildings, pipe lines, ships, and machinery, and shows that experiences gained in this type of construction have their influence upon all other activities where tight joints come into consideration.

The choice of the various materials and the technique of their application depend to a high degree on the problems of surface

[1] From *V.D.I. Nachrichten*, Berlin, June 19, 1929. This report, given by the author at this year's session of the Scientific Council, is based on the researches instigated and promoted by the V.D.I.

[2] Prof. Dr. Ing. Director, Verein Deutscher Ingenieure. Life Mem. A.S.M.E.

protection. For that reason the matter of protective coatings is attracting widespread consideration, even from public utilities (railroads, post office), and in this way has become the subject of considerable discussion. While on the one hand experts are concerned with the problems of color standardization and dyestuff standardization, on the other hand they have also undertaken the physical and chemical testing of finished paints and pigments and have deduced valuable information regarding the durability, resistance, etc., of paint films as well as an explanation of their colloidal properties.

In the realm of actual metal working we see investigators earnestly occupied with research work on cutting processes. While originally attempts were made to gain knowledge of machining by lathe cutting only, recently through the active cooperation of the German Iron and Steel Institute, which made large quantities of material available, work has been going on to explain the connection between practice and theory in milling processes and to gain similar guiding values, such, for instance, as the committee for economic production already has at its disposal.

Researches are being extensively fostered and pursued by private and public economic enterprises which are interested in the life and durability of wire ropes. The basic theories developed in this manner furnish an important means for the computation of wire ropes, and also are useful in the manufacture and operation of elevator cables.

HEAT-TREATING OF METALS BEING STUDIED

Among the problems of production those of the heat treatment of metals, namely, annealing, hardening, surface treatment, occupy the front ranks in research activities. Using the investigations of the state committee in Berlin and elsewhere on working-time determination as a basis, the working committees of the workers' union of the A.D.B. (Federation of German Engineers-in-Charge) are at present occupied in creating the bases for piece-time rate determination in the technique of forging, of stamping, of instrument construction, and of woodworking. This movement is now extending into the textile, rubber, and ceramic industries and even to agriculture and forestry. The shaping or machining of material is also the subject of lectures and courses in the A.D.B.; these have found an active participation far exceeding all expectations. A collection entitled "Proper Drafting-Room Practice" (Werkstattsgerechtes Konstruiren), which is at present in preparation, gives the practical designer the opportunity to view every aspect which must be considered in the making of a design from standpoint of economic production. Much more might be said about the manner in which the committee on gears might attain a closer connection between institutes of technology and actual practice. "The Treatment of the Theory of Gears at the Institute of Technology" is the title of a memorandum according to which a gear "synthesis" is to be created. Authorities in the study of machine parts desire above all that the latest scientific data on the construction of machines be made available to engineers in a thoroughly comprehensive manner without imposing a heavier burden upon the curriculum.

The same aspects which turn our thoughts to economical working processes hold good in the main for all manufacturing and production enterprises, including power and heat economics. Among the numerous activities in these fields, only a few of the especially noteworthy ones may be mentioned. The comprehensive experiments with high-duty chain-grate stokers with sectional divisions or chambers gave favorable results and led to the determination of characteristics of stoker-fired boilers; they show that the chain-grate furnace is in every way equally as efficient with regard to flexibility and firing rapidity as the pulverized-coal furnace. It must be borne in mind that great difficulties are encountered in the introduction of pulverized-coal firing for locomotives, as an example. Although it has been possible to raise the combustion-chamber load to as high a degree as is required by the locomotive, the problem of economic coal pulverization has in the interim not been solved; thus the future of pulverized-coal locomotives is still doubtful.

METHODS DEVELOPED TO STUDY POWDERED COAL

The extensive use of pulverized coal for power generation seems to make it desirable to determine exactly every phase which is important in the preparation of pulverized coal. On the instigation of the Government Coal Council, work has begun and is already partially concluded which includes the development of suitable measuring instruments for coal dust and the development of measuring methods to determine the degree of fineness and the standardization of terms. Although for the present these indications merely represent projects, they may be regarded as a basis for the setting up of rules for performance tests.

The task of economic power generation and all that depends upon it is of especial interest to German engineers, as next year in Berlin the second large World Power Conference will be held, for which the necessary preparations are already under way. The preliminary work for the formation of professional committees led to their appointment in the early part of 1929. The Society of German Engineers (V.D.I.) considered it a duty to facilitate the administrative work of the professional committees by placing its house and experienced workers at their disposal.

That the World Conference stands under the aegis of the economic power-generation industry should be an incentive to engineers to carry the ideas of economic production into those realms which formerly were open to us in only a slight measure. An activity of this kind is in the field of cost accounting and distribution. The committee on costs of the V.D.I., in its preparatory work, worked out a course in industrial cost accounting as well as a collection of memoranda concerning the entire field of industrial accounting. The works of a group of experts of distribution engineers and committees are to be published in a series of papers, "Wirtschaftliches Vertrieb" (economic sales or distribution), the first pamphlet of which, "Wirtschaftliches Quellennachweis für die Durchführung van Marktanalysen ("Statistical Bibliography for the Preparation of Market Analyses") is meant as a preliminary work toward making available market analyses for practical application.

The training of engineers and of all those actively engaged in industry must not be neglected while we are engaged in spreading all available knowledge. It is not a question of making money; even if the German machine industry had really acquired this art, we engineers would not consider economic results the goal of our life's work nor the true significance of engineering. To realize the cultural significance of this work, the history of engineering must be correctly understood. Obviously it cannot consist of merely stating new facts constantly nor in adding to those already known, but must, above all, point out the development of engineering and the meaning of the work done by great men. The history of great engineers can create a fountain of youth from which new joy and enthusiasm for the great work in engineering may spring again and again. The flame of enthusiasm for lofty aims must be kept alive from generation to generation.

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FLAPPING FLIGHT OF A GULL. THIS GIVES A SINUOUS MOTION TO THE CENTER OF GRAVITY OF THE BIRD

Scientific Studies of Natural Flight

Gliding, Flapping, and Propelled Flight Used by Birds in the Air—Some Better Adapted Than Others to One or Another of These Processes—Resources for Maneuvering Make of Them Gliders, Airplanes, or Helicopters

BY MAURICE BOEL,[1] CHARLEROI, BELGIUM

FLIGHTS of birds, insects, certain mammiferous animals, and some winged fruits and seeds are referred to as natural flights. They are of particular interest in connection with practical, theoretical, and scientific studies of flying. A considerable amount of research is still being conducted in hopes that the information gained from natural flight will aid in solving the many problems of aerodynamics.

The science of aerodynamics may be considered as still in its infancy as it was born scarcely twenty years ago. Its development during the last few years has been very rapid. By reconciling or coordinating recent aerodynamic successes with the discoveries of earlier physiologists, the author has been able to evolve a theory of natural flight. This theory has been strengthened by evidence and proof collected on three missions abroad, in Senegal, Argentine, and the South Seas.

It is a noteworthy fact that the utilization of air resistance as a means of movement from place to place, or the act of flying, is not confined to birds. It is a form of locomotion adopted by several types of organisms. Chief among these are insects, certain mammiferous animals, flying fish, and even winged seeds, known as anemophiles, meaning literally, "friends of the wind."

It is difficult to discuss the subject of natural flight without first considering briefly certain rudiments of aerodynamics. This is the science by which one studies the resistance of the air, which is a force in the same category as, for example, weight.

In studying a force, one seeks to determine in every possible case, the four elements of (*a*) intensity, (*b*) direction, (*c*) sense of direction, and (*d*) point of application. So far as the study of the mechanism of natural flight is concerned, the first three elements need not even be considered. The fourth is important.

In the case of a heavy body the point of application of force (weight) is represented by the center of gravity. In the case of a body which has no material shape, the point of application remains motionless, no matter what position that body be placed in. This does not apply, however, in the case of the center of pressure upon a wing.

[1] Professor, Charleroi University.

Presented at a meeting of the Aeronautic Division of the A.S.M.E. Detroit, Mich., June 28–29, 1928. Abridged.

It is known that the effect of air resistance varies with each change of the angle of incidence, and occupies a position generally comprised between the leading edge of the wing and the center of its depth. Displacement of the pressure center may affect every action of the wing. In those wings with which this study is concerned, the pressure center moves toward the leading edge. When this displacement occurs, the incidence is decreased.

It is by the apt utilization of this phenomenon that the mechanism of natural flight may be explained. The aptitude to take advantage of it is found no less among birds than among insects, certain winged seeds, etc. In this connection there exists no great difference between the rapid wing movements of the swallow, the soaring flight of the flying squirrel, and the fall of the seed of the sycamore tree. In the case of anemophile seeds, only one mode of passive flight is possible. These organisms must glide. But there are several distinct forms of gliding.

Some seeds fall vertically, as for instance that of some akenis, and that of the strophanthus, a plant indigenous to central Africa. Other seeds, such as that of the zanonia, which is native of Java, describe a particularly graceful glide. Pine cones and the seeds of the sycamore tree turn while falling and reveal themselves as true helicopters. Each of these forms of gliding is determined to some extent by the shape or arrangement of the carrying surfaces, and especially by the position of the center of gravity.

Naturally, all stable-gliding bodies adopt, in relation to their trajectory, such a position that the resultant air resistance passes through the center of gravity. This position, which in a wing is defined by its angle of incidence, depends therefore on the position of the center of gravity.

Having recognized the phenomenon by which the pressure center is displaced, it is easy to understand, for example, that the parachute of the strophanthus must adopt an incidence of 90 deg. and fall vertically. This, of course, is because the formation of the strophanthus is symmetrical in its relation to a plumbline. In the zanonia, owing to the position of the seed, the center of gravity is moved to one side, which naturally becomes a leading edge. It can only balance itself at a small angle, and consequently is compelled to glide.

The sycamore seed, although more complicated in its struc-

ture, benefits nevertheless by the same property as does the zanonia. But if its wing were not weighted at one side it would be unable to turn in the air. This may be proved by a very simple demonstration. An apparatus similar to the sycamore seed may be fashioned by shaping a small slip of paper to represent the wing. It is then weighted at one end with a paper fastener, the points of which are bent back. In this manner one obtains a rough working model of the seed. But it will be observed that the model does not turn while falling. To insure the desired effect it suffices to weight one edge merely by

PRIMARY FEATHER OF A PIGEON SHOWING THE SHAFT AND THE RELATIVE LENGTH OF THE BARBS, SHORT IN FRONT AND LONG BEHIND

inserting an ordinary pin along it. In this manner the center of gravity is altered and the model at once acquires the properties of the sycamore seed. In each of these three demonstrations the angle of incidence is determined by the position of the center of gravity.

When the center of gravity lies on an axis perpendicular to that of the carrying surfaces the angle is 90 deg., as in the case of the strophanthus. When the center of gravity is near one of the edges, as with the zanonia and the sycamore seed, the incidence is less than 90 deg.

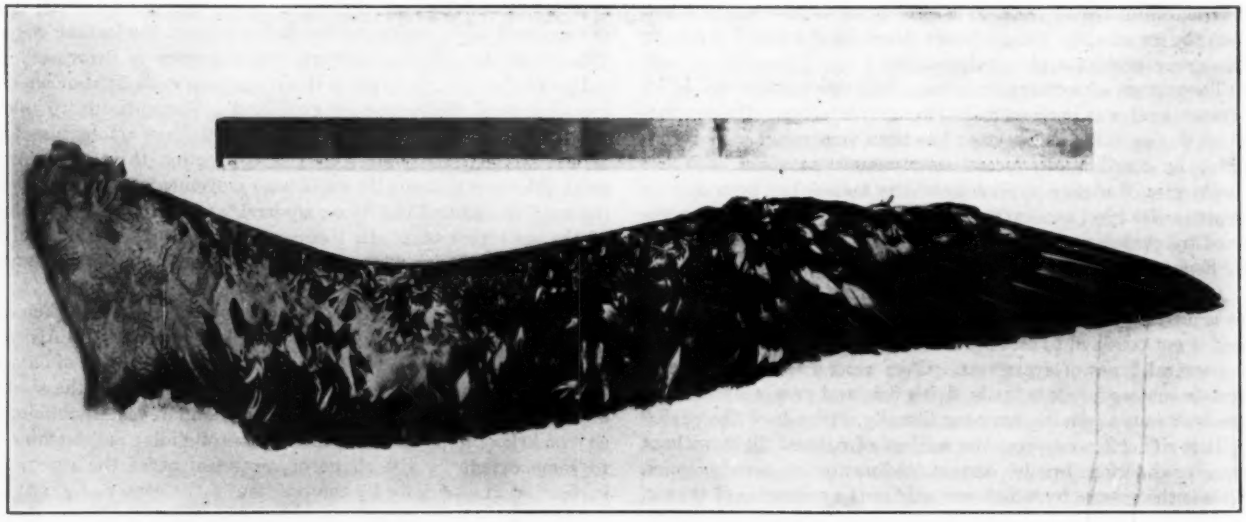
The wing of an insect and the feather of a bird, which is to some extent an elementary wing, are active organs. The adjective "active" is used in direct opposition to the passive feature of parachutes and gliders which have just been discussed. These organs are of very distinct structure.

The wing primaries of birds, for example, are composed of quills of unequal length, short in front, long toward the rear. A similar arrangement is noticeable in most insects. Among the numerous nerves which traverse the delicate membranes of their wings there is nearly always one, more robust in appearance, which is situated close to the leading edge and runs parallel to it.

Imagine an aerodynamic square, or plane, of similar formation, and suppose it is subjected to air resistance. If the center of gravity is at the axis, the plane will take such a position or incidence that the pressure falls upon its axis. In any other position it would be subjected to a moment that would cause it to turn, and would necessarily bring it to the position which has just been defined. In other words, such a stabilized plane, traversed by any axis whatsoever, will adopt an incidence determined by the position of this axis to the depth of its feather or of its wing. If it is situated at the leading edge, the angle will be nil, and the air resistance will not manifest itself in a form which can be utilized. If the axis passes through the middle, the angle of incidence will be 90 deg. Finally, if the axis is situated between these two extreme positions, the incidence will be between zero and 90 deg., and the result will give a serviceable component.

To appreciate this peculiar property one has but to hold a bird's feather in the hand at arm's length, and wave it back and forth, up and down, leaving the stem free to turn in the palm of the hand. Manipulated thus in a horizontal plane the feather exerts a sustaining force similar to the propeller blade of a helicopter, which would be animated by alternate movements. Maneuvered on a vertical plane, the feather exerts a propulsive force, also of alternate movements.

All birds utilize this property of wing primaries. The characteristic "feathering" birds, such as the duck and the pigeon, adopt it only when soaring or when rising vertically. In a slow-motion film it is possible to note that in these circumstances the wing primaries are separated, outstretched like the fingers of one's hand. In that manner they consequently become independent of each other. Each feather acts individually, and beating in a horizontal plane, each can act as a sustaining force.



THE WING OF AN ALBATROSS OUTSPREAD. THE SCALE IS ONE METER LONG (39.37 IN.)

Certain birds, such as the vulture and the condor, make constant use of this phenomenon. They fly by slow flapping movements, the wing primaries always separated and animated by a fuller movement than that of the rest of the wing. This flight is similar in every way to that of the airplane. The wings serve them literally as carrying surfaces. The wing primaries act as propellers, giving an equal horizontal force, or traction, both in climbing and descending.

If one were to cut the front quills of all the wing primaries, the feathers would lose their peculiar property. Set in motion in the air they would adopt an angle of incidence of nil like a weathercock or a flag, and could no longer serve as propellers.

This has already been proved by experiment. A vulture whose wings had been modified in the manner described was unable to "take off." Launched from the edge of a high cliff, he made a determined effort to flap his wings, but finally resigned himself to a gliding landing on the beach. The same procedure is followed by small birds, as the hummingbirds, which fly by rapid wing flapping, and by all other birds when landing or soaring. It can be noticed especially in regard to the wings of ducks about to alight. The birds hold their bodies vertical, their wings flapping in full horizontal, and the wing primaries separated one from another.

The flight of such feathering birds as pigeons, seagulls, swallows, etc., is of a different order. From evidence collected by Marey, it becomes obvious that the essential features are:

(*a*) A trajectory of the wing tip in the form of a closed curve, if one imagines the bird flapping its wings without advancing itself in the air.

(*b*) A sinuous, or undulating, trajectory of the bird's center of gravity.

By reconciling these two phenomena it is found that the center of gravity rises when the wings are lowered and falls when they are raised.

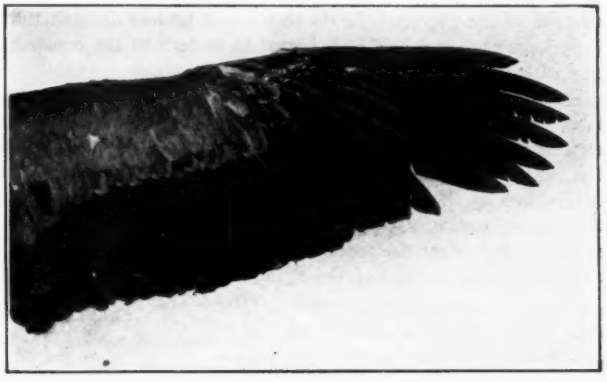
It is known that at the moment when the center of gravity is raised, the air resistance is greater than the bird's weight. This air resistance, at a determined speed, depends upon the importance of the resistance coefficient, which in turn depends upon the incidence of the surface.

Now, when the wing is carried forward, it creates by a relative recoil of the center of gravity, an increase of the angle of incidence and of its surface. The position is therefore especially favorable to the "lift," and if a bird makes use of the muscles of depression of its wings at this moment, the result is not a lowering of the wings, but a raising of the body. Hence the raising of the center of gravity.

When the wings have reached the lowest point of descent they partly close up like a fan. The effect of this is a low angle of incidence and a reduced surface. The bird descends in a glide, sacrificing all or nearly all the height which it had attained at the cost of its energy, yet at the same time obtaining an increased speed. In other words, the feathering flight of birds may be likened to the flight of a glider which has been lifted to a certain height and released to glide down again after covering a certain distance, and which is then raised once more, to repeat the performance again and again. By this means the glider can be made to travel any given distance, provided, of course, that it be raised and reraised from the ground a sufficient number of times.

The progress of the flying squirrel across a forest is a truly remarkable operation, and one that bears a strong resemblance to the feathering flight of birds. This animal, it is said, climbs a tree and launches itself from it in full flight to the foot of a neighboring tree. It then climbs this second tree and flies to the foot of a third, and so on. The flying squirrel's mode of locomotion, like that of the glider, consists of a series of gliding descents.

The author opposes this theory to the theory known as "pulsation," which is at present supported in Europe by the adherents of Nimführ and Gillet, and in a slightly different form by Oemichem. According to these various authors, the flapping of wings possesses a distinct virtue of its own, and they tacitly admit, as, for instance, with the helicopter, the independence of speed and of the load factor.



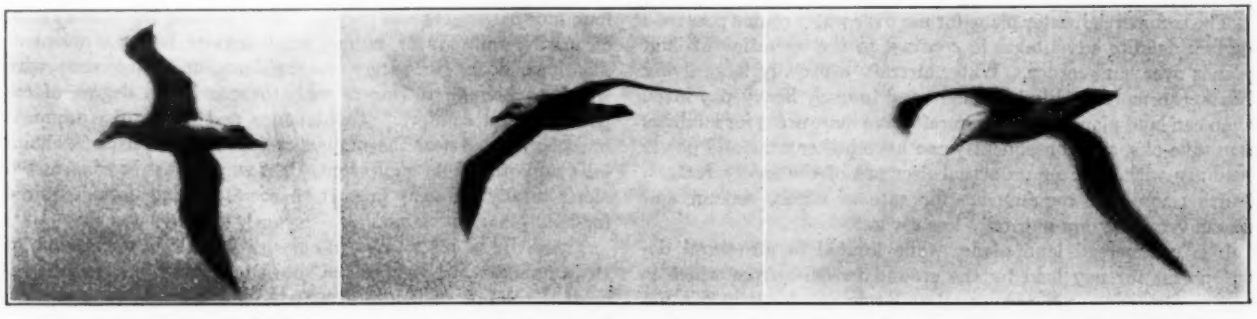
WING OF A VULTURE. THIS BIRD WEIGHED 4.95 LB., HAD A CARRYING SURFACE OF 5.87 SQ. FT., AND A WING SPREAD OF 7.05 FT.

The feathering flight of the bird is comparable to that of the airplane; also speed is dependent upon the load factor. When the load factor is high, the bird must fly fast. When it is low, the bird will fly more slowly. This is a theory which the author has verified in Belgium with the aid of pigeons belonging to certain well-known breeders; also, for more than three years, with pigeons from a military cote which was placed entirely at his disposal for this special purpose.

As a result of the numerous methods employed and the experiments conducted under these conditions, it was shown:

(*a*) That racing pigeons are usually loaded to between 6 and 10 kg. (from 12 to 20 lb.) per square meter.

(*b*) That 6 kg. is too light (because the flight is consequently slow) and that 10 kg. is too heavy and causes the bird to tire.



ALBATROSS GLIDING. THE VIEW AT THE LEFT SHOWS BIRD WITH WINGS SPREAD OUT; THE OTHER TWO VIEWS HAVE WINGS BENT SLIGHTLY

Further, that champion pigeons are usually loaded to between $8^1/_2$ and 9 kg. (or between 17 and 18 lb.) per square meter.

Following out these deductions it was possible to suggest to the Belgian pigeon racers an all-around improvement in the performance of their birds by means of an artificial reduction of the excessive surface of certain wings, and by the cultivation of pigeons with narrow wings, and an exactly proportionate surface.

The results thus obtained, which in every case were fully demonstrated, confirm the author's theory to a certain extent. The most satisfactory verification, however, would be provided by constructing an apparatus that would function in the same manner as the pigeon. To do this would be less difficult than is perhaps apparent, and it is hoped to undertake the construction of such an apparatus this year.

Each living organism capable of flight, whether seed, insect, bird, or mammiferous animal, makes good use, as an aid to its own locomotion, of the phenomenon known as displacement of the center of pressure. In each case the angle of incidence is determined by the position of the center of gravity, or by a motive nerve, compelling the sycamore seed to utilize the same mechanism as does the feathering bird, while the flight of the latter is similar to that of the flying squirrel.

From the practical aspect natural flight is no longer regarded as a form of aviation, excepting only in relation to the flying of airplanes. It has yet to be proved that man can successfully imitate the animals in this respect, and it is not worth while even to attempt to do so.

Among the observations made, there are several lessons which might profitably be learned by aircraft constructors. Many birds, particularly the albatross, are "constructed" with especial care. Moreover, birds possess a greater "speed range" than the majority of aircraft, while the energy which they expend when flying is relatively less than that of machines.

Here, then, are qualities more important than can be fully appreciated, and which will eventually be embodied in the construction of airplanes that already possess a superior speed. In other words, the theory of natural flight does not introduce a new machine. It introduces merely a few remarks which will assist in perfecting existing aircraft, of which there is every reason to feel very proud.

The conquest of the air is one of the most splendid triumphs of modern times, and one that in recent years has permitted the accomplishment of numerous brilliant flights. Today, man is doing nearly as well as the birds. In a little while he will be doing even better.

Some Phases of Seaplane Transportation

By J. T. TRIPPE,[1] NEW YORK, N. Y.

WITH its ability to operate from either land or water the amphibion is obviously the most flexible type of equipment available. It has been an ideal instrument in the development of the international air lines which combine both land and water routes. It has speeded up the establishment of regular service over these air lines by eliminating the necessity of completing water and land airports before service could be started.

The commercial water plane for use over water routes possesses certain definite advantages in contrast to the operation of land planes over land routes. Water aircraft, especially large flying boats, can more readily be constructed to carry heavy pay loads than can land planes. Such aircraft have more areas for landings and take-offs, and consequently can have higher wing and power loadings with little or no actual decrease of the safety factors. Furthermore the requirement for rate of climb, ceiling, and maneuverability are naturally less severe.

The commercial land plane, while limited in structural development for pay load by the ground facilities from which it must operate, can yet accommodate larger pay loads in relation to its gross weight than can a water plane. It is a much faster craft, has a higher reserve power, is more flexible in performance, and permits lower wing and power loadings.

Both types of equipment, too, have definite disadvantages from the standpoint of operations. The flying boat, for instance, is directly affected by the extent and nature of water landing and take-off areas. This factor involves consideration of the amount of other water traffic, localized water conditions, air conditions, natural under-water obstructions and other items.

Land planes, for their part, involve a considerable investment for airway construction. Operating bases, whether for land or water planes, naturally require large expenditures for maintenance machinery and personnel. In addition to these terminal facilities, however, land planes also demand intermediate landing fields located at convenient intervals along the routes on which suitable runways must be constructed, and adequate ground facilities installed to permit their use as emergency fields.

Water-plane transportation requires specialized facilities for handling passengers and cargo. These include the construction of marine railways or ramps, small service boats, convenient moorings, docks, or barges, fueling lines, and equipment with which to handle passengers with the maximum degree of expediency and comfort. Maintenance and overhaul equipment must be located near the water, together with windlasses, chain-falls, and other light equipment, all of which must be constructed along totally different lines from corresponding units required for land-plane operation.

There will be a tendency to enlarge the field of operations for the amphibion. Later, as the volume of traffic justifies the increased cost of such improvements, and international airways become highly perfected, it is probable that the trend will be away from amphibions, and toward the operation of flying boats on the over-water routes, and land planes on the overland routes. One of the major factors which may bring about this change is the necessity for the use of equipment which will carry the largest pay load at the lowest operating cost.

There are general features of the amphibion which must be incorporated on commercial flying boats. One of the most important of these is a retractable taxiing gear which will permit the boats to be brought out of the water under their own power.

One of the most important requirements of the air-transport operator is that manufacturers will make available equipment designed to fulfil the needs of commercial operation, and that the operator will be able to purchase this equipment at a reasonable price with the certain knowledge that he can maintain it in operation at a reasonable cost.

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[1] President and General Manager, Pan American Airways, Inc., New York, N. Y.

Presented at the Great Lakes Aeronautic meeting of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS at Cleveland, Ohio, August 24 to 31, 1929. Abridged.

A Dynamic Museum to Reveal Man's Technical Heritage

By WALDEMAR KAEMPFFERT,[1] CHICAGO, ILL.

OVER and over again we hear the pronouncement, "That ought to be put into a museum!" And the cause is—what? A curiously twisted shell; the antlers of two deer that perished, locked in mortal combat; the egg with two yolks that turned up at the breakfast table; the chick that was born with three legs; the carved whalebone walking stick that has been in the family for generations; the stone which was found in the woods and which, when held in a certain position, bears an uncanny resemblance to the features of George Washington. From the days of the Greeks and the Romans down to our own time the oddity and rarity of an object determined its preservation value. Thus it has come about that the older a museum happens to be the more likely it is to contain collections of what are mere curios. The natural history museum still labors under this false standard, despite its newer purpose of teaching anthropology, biology, botany, and related sciences with an eye to a visual system. Hence we find in the natural history museums of Europe and America, Egyptian mummies and the boneless, shrunken heads of cannibals housed under the same roof with Roman bathtubs, primitive flint weapons, dinosaur skeletons, Javanese theatrical costumes, butterflies, and specimens of woods.

The systematic cultivation of art was in part responsible for the change that has gradually taken place in museum practice. A masterpiece of painting or sculpture is necessarily a rarity, and so it naturally came about that a collection of artistic rarities, limited as it was to one field of endeavor, was bound to be more or less coherent and therefore to serve a higher and finer educational purpose than a miscellany drawn from many sources.

Now a technical museum has one inestimable advantage over an art museum. A painting by Fra Angelico or Albrecht Dürer must be an original. No copy can ever satisfy the eye completely. Stephenson's "Rocket" has an undeniable sentimental value, but an exact replica will teach all that the original can. It may matter much to the director of an art museum that a certain painting in Rembrandt's earlier manner is to be found in Amsterdam. But the technical museum's director will not grieve because South Kensington possesses the "Rocket." It follows, therefore, that a technical museum can always be far more coherently and systematically arranged than any art museum. Technical principles are all-important in the technical museum. And yet despite this fact Germany still stands alone in having a technical museum in which the more important phases of technology may be surveyed systematically.

Descartes it was who first saw the educational value of a technical museum. Why not collect the tools and utensils of the important handicrafts, present them logically in a place where the public and artisans could study them, and learn something of the practical arts? The proposal smoldered for generations. A colossal upheaval, something comparable with that which followed in the train of the recent World War, was necessary to give human thinking new purpose and direction. That upheaval was the French Revolution. The old Bourbon notions of government and its obligations to the people had hardly been swept overboard and the blood of aristocrats had hardly clotted on the scaffolds when France carried out Descartes' suggestion. A new era had dawned. The technician was no longer regarded as a low creature, somewhat higher than a barber, but as a molder of a new order of society. His tools and his processes became of economic importance. The Conservatoire des Arts et Métiers was built. It stands today, the oldest technical museum in the world, with its magnificent collections of historic engineering and industrial relics. Yet its name indicates its true purpose. As a *conservatoire* it is but a repository and not a true museum. Indeed it is still frankly conducted as an adjunct of the École Central, of which it forms a part. The models are taken from their cases and wheeled on narrow-gage flatcars into the classrooms.

To be sure the public is admitted into the Conservatoire, as it is to the Louvre and other museums of Paris, but only a feeble attempt has been made to trace systematically the evolution of the major branches of science and technology. The models and instruments are preponderantly French. There is Cugnot's historic artillery tractor, for example, one of the first engineering attempts to substitute the steam engine for the horse; but you look in vain for other machines which would make it possible to trace the influence of that priceless, historic mechanism on the locomotive and automobile. You see Ader's famous Avion, Blériot's cross-Channel monoplane, and other epoch-making French contributions to aviation.

But no engineer could write even the roughest outline of aviation's slow, painful, tragic yet irresistible rise with the aid of that collection alone.

So the Conservatoire remains a distinctly national storehouse through which the public may wander and learn what it can of past engineering efforts to harness energy in the service of man.

The principles of science are not yet the possession of the many even though the age is essentially scientific; and the effects of scientific research, invention and industrial progress are felt rather than understood. When Giotto finished a picture all Florence was jubilant and stopped work to celebrate the completion of a masterpiece which was not only a thing of beauty but which expressed the emotions of an art-loving city, all of which was as it should have been, at a time when art was scarcely less important than religion in the life of Italy. Science has usurped the place of art. It is perhaps asking too much that a city declare a holiday and rejoice at the discovery of the X-rays, but it is not too much to expect an intelligent public to discover what X-rays mean to mankind as they find wider and wider application. There is no lack of interest in technology, as the small crowds testify that are fascinated by the stiff but efficient movements of a steam shovel, excavating a huge hole on the site of some future office building. But the people have no opportunity to gratify that interest, no opportunity to survey the technical and social progress of the past and evaluate the status of the present. And it is the primary purpose of the Museum of Science and Industry founded by Julius Rosenwald to create that opportunity.

[1] Director of the Museum of Science and Industry.

Motion Exhibits Are First Introduced

The next technical museum of historic importance is undoubtedly the Science Museum of South Kensington, London, an outgrowth of the Crystal Palace Exposition of 1851. Again we find a collection primarily national in character. Here and there machines of other countries are to be found—among them the original biplane on which Orville Wright first flew with an engine in 1903. South Kensington, however, made a new and startling contribution to museum technique. Some of its machines moved automatically or they could be placed in operation by the visitor himself by the mere pulling of a lever, the turning of a crank handle, or the pushing of a button, so that pistons could be seen reciprocating in sectioned cylinders and the operations of complicated mechanisms could be studied. The effect on the public was unmistakable. The Science Museum of South Kensington is today one of the most popular institutions in the British Isles.

It remained for Dr. Oskar von Miller, a man of remarkable energy and imagination, to push this new principle farther. Von Miller is an engineer. He championed alternating current in Germany as Westinghouse did in this country. He organized the first electrical exposition that Germany ever saw. With no museum experience behind him, but with much experience in driving home technical facts to the public in expositions, he conceived a technical museum which still stands as an unrivaled achievement in a special field of visual education. In 1903 he laid his conception before a convocation of leading engineers, scientists, and industrialists of Germany. The principle of letting the public experiment on its own account was to be applied, not merely casually, but systematically throughout the museum. Moreover, it was to be made possible to trace the entire evolution of the more important sciences and branches of engineering. To heighten the dramatic effect of motion, machines were to be placed, so far as possible, against realistically painted backgrounds to disclose the circumstance in which the principal industrial processes are carried out.

In a year the now famous Deutsches Museum was a reality, housed in the abandoned National Museum of Munich. The rulers of the German states, municipalities, manufacturers, scientists, and engineers contributed either exhibits or money. Even the building material of the new structure, which was erected on an island in the Isar and which was formally opened in 1925, was partly donated by industry. Self-sacrifice made the Deutsches Museum what it is today. Von Miller gives his services free, and his curators content themselves with salaries which are smaller than those they could earn as practicing engineers or university teachers. This energy and devotion have made it possible to collect some sixty thousand machines, models, pictures, and other exhibits, the whole systematically so arranged that as the visitor walks through nine miles of hallways he walks through centuries of technical progress.

That such an example was bound to inspire American visitors was a foregone conclusion. At least four similar technical museums are to be established in the United States, and the number is not too large when the immensity of the country is considered. One of those on whom the Deutsches Museum made a profound impression was Mr. Julius Rosenwald of Chicago. He laid before the Commercial Club of Chicago, a body of the city's most eminent business men and bankers, a proposal to endow a Chicago technical museum with the sum of $3,000,000 to be spent for equipment alone. The club undertook to administer the fund and appointed a board of trustees. The city likewise responded. In Jackson Park stood the old Fine Arts Building, the last crumbling reminder of the World's Columbian Exposition of 1893. St. Gaudens regarded it as "the finest thing done since the Parthenon." An opportunity was presented to perpetuate a structure which the city did not know how to utilize and which it did not wish to destroy. The South Park Commissioners were authorized by popular vote to issue $5,000,000 in bonds for the purpose of reproducing the building in permanent form. Thus was born the institution which was provisionally called the Rosenwald Industrial Museum, but which, at Mr. Rosenwald's insistence and over the protest of the board of trustees, is henceforth to be known as the Museum of Science and Industry. By 1933 it is hoped that the museum will be open to the public, although there is no intention of filling by that time halls as vast as those of the Deutsches Museum.

New Museum Will Include Best Features of All

The sponsors of this new museum determined at the outset that it was to be no mere slavish imitation, but that it was to utilize the experience of Europe as a foundation and to develop the technique of Munich. All the technical museums of Europe content themselves with explaining the principles of science and engineering. Is this enough? Should we not show the effect of engineering on society? Until the steam engine was introduced life was outwardly no different from what it was in ancient times. Political progress had been made, but little technical progress and in some respects technical retrogression. Men still traveled by horse or boat. The roads, on the whole, were not as good as those that tied the Roman empire together. With the steam engine came the new spirit of science, with its objective attitude, patent protection, and a realization of what controlled energy could do. The social and economic effect was profound. Civilization was completely transformed, and this transformation is now proceeding at an accelerated tempo. If the scientist and the engineer can change the face of society, have we not here something to interpret? And so it was decided that European practice was to be amplified in Chicago. Machines were to move as in Munich, but in addition their effect on society was to be shown. What is the chief function of the scientist and above all the engineer? To create an artificial environment for man. What we see about us, these electric lamps, these motors, these street cars, these automobiles, these push-button conveniences are all inherently unnatural and yet natural because we cannot imagine society without them. Not only the processes but the social functions of the engineer need to be explained.

The staff of the museum has already found that if this conception is to be realized there must be a radical departure from European methods. In Paris, South Kensington, Munich, and Vienna the individual inventor is glorified. A certain chauvinism is inevitable. Thus in Paris, Ader is the inventor of the airplane; in Germany it is Lilienthal; in Austria, Kress. Who invented the telephone? Reiss, according to Munich. Similarly Wheatstone is in England the inventor of the telegraph, and Steinheil in Germany. Munich frankly accepts Goebel as the inventor of the electric incandescent lamp, despite the work of Edison.

In any social or cultural interpretation of science and industry the race is more important than the individual. The technical heritage of the engineer, the cultural circumstances in which he works are as important as genius; for genius can express himself only in terms of his heritage and his times. Elizabethan England had much to do with Shakespeare's plays. Leonardo and the lady known to us as La Gioconda could not possibly have danced a fox trot in fifteenth century Italy, simply because jazz could be composed only under a peculiar combination of social circumstances and in a cultural atmosphere then non-existent. Somehow great achievements in science and art are introduced when society is ready for them. Something ferments in the social organism, and the result is the Parthenon, the con-

quest of Persia by Alexander, the Perseus of Cellini, the steam pump of Newcomen and Savery, the condenser of Watt, the locomotive, electric energy. Society is under a cultural tension. It relieves that tension by short-circuiting itself through a great artist, scientist, engineer, military leader, or business entrepeneur. He is the fuse that blows. It is significant that so many technical achievements appear almost simultaneously. The telegraph is conceived in different forms at about the same period by half a dozen different men. Bell, Gray, and Reiss invent a telephone at about the same time without knowing of one another's work. Goebel, Swann, and Edison, to mention but three, simultaneously try to develop the incandescent lamp. Half a dozen inventors on both sides of the Atlantic experiment with electric traction before there is even a central station.

In the Museum of Science and Industry of Chicago the scientist and engineer will therefore be regarded as the medium through which the race expresses its technical yearnings. His exceptional gifts will not be belittled, but he will not be hailed as the "wizard" of the newspapers. He has had a vast technical heritage. A hundred dead generations aid him. The social and economic pressure of his own time dictate the manner in which he shall solve the problem to which he addresses himself. Five hundred centuries of experimenting, sometimes vain and sometimes successful, flower in him. The spirit of Newton is in every engineer who has made the laws of gravitation part and parcel of his thinking. Carnot lives again whenever a new turbine is designed. Hence in this new type of technical museum which is to be established in Chicago there will be no "first" inventor of anything. It will be apparent that every experimenter in the field of science and technology adds something to his heritage. Evolution is as vital a force in science and engineering as it is in biology. If this were not so there would be stagnation. As he wanders through the halls of the Museum of Science and Industry in Chicago the visitor will be constantly reminded of the causative factors that have played their part in the development of invention.

To Show the Effects of Science and Invention

When it comes to interpreting the effect of science and engineering on society, a more difficult task is encountered. Much of our progress is intangible. It is a state of mind, partly contentment because of the greater facility with which goods are now produced and transported, partly dissatisfaction because of the conditions that have been created by the machine. Fortunately states of mind concern the statesman rather than the engineer. What can be shown in a museum are the effects of science and invention on society as a whole—the change which has been brought about in the home, the development of the industrial community, the consequences of swift transportation by land, sea, and air in stabilizing prices and intermingling peoples. We stand on solid ground, for example, when we show how the skyscraper followed the elevator and how mass production attended the introduction of the steam engine. In electrical communication we are greeted with the spectacle of the human personality disembodied sense by sense and flashed through space to be reassembled in part at some remote point. For what is it that we do when we telephone but transport our mouths and ears through space while we remain at our desks? And television—what is that but a translation of our images, while our bodies remain at home? Surely a visitor to a technical museum is entitled to this sort of interpretation as well as to an opportunity of studying the mere operation of an electrical device or machine.

We cannot ignore the fact that the engineer has sometimes thrown a bolt into the machinery of politics and economics. Whitney, for example, invents the cotton gin. Cotton assumes a new importance. Slaves must be imported in shiploads to pick it. A bloody civil war must be fought to settle a great social problem created by slavery. Should not the cotton gin be explained socially as well as technically? Coal tar, a disgusting ooze that cannot be turned into streams lest it poison fish or buried lest it kill vegetation, becomes of economic importance when Perkins discovers mauve. Surely it becomes necessary not merely to reveal what is now done with coal tar, but how organic chemistry has transformed Germany and enabled her to supplement natural products with compounds of which nature never dreamed. And steel—is it enough to show the evolution of iron and metallurgy? We call this the age of steel, and with reason. But what do we mean? The steel age becomes intelligible when we interpret iron ore in terms of society.

Even individual machines lend themselves to this method, still new in museum technique. Every motor is an artificial organism that supplants the human body and its senses. What is an orange-peel bucket but a huge steel hand that clutches tons where the hand clutches but ounces? And what is the hammer of a drop forge but a huge steel fist? Somehow the human frame gains in dignity and importance when it is thus interpreted. Brains loom up as man's most precious possession.

One of the most interesting halls will be that devoted to what may be called the news of science and technology. If a few centuries hence one of our descendants were called upon to write a history of the United States on the basis of news published in the American papers of our time the picture he would form of life in the early twentieth century would surely be distorted. Only the advertisements would save him from concluding that it was impossible to venture abroad without being robbed, assaulted, or murdered, that public officials were usually corrupt and that our private lives were scandalous. Since we gossip in print chiefly about death and destruction, the great technical accomplishments of our scientists, the important news of the day, receive short shrift. The Museum of Science and Industry has no intention of competing with the press, but its officers conceive it to be one of their principal tasks to show how the pioneers of science, engineering, and industry are pushing on and establishing new frontiers.

A Vision of the Technical Future

Pure speculation will play no part in the Museum of Science and Industry, and yet the people of Chicago will catch some glimpse of the technical future as they wander through this new hall devoted to proposals which are practical and which are therefore being seriously considered by states, municipalities, and corporations. Of late we have heard much of the English Channel tunnel, for example. No engineer will deny the feasibility of stepping on a train in London and of traveling under the English Channel at a speed of sixty miles an hour and alighting in Paris a few hours later. If the Museum of Science and Industry were now in existence there would be a model of that tunnel in the hall devoted to Concepts of the Day, so that Chicago might see how the engineer would make intercourse between France and England easier. Television has become a reality. If that hall were in existence we would display in it a model to make the underlying principle plain and to forecast such social effects as the possibility of producing a play in Chicago and of hearing it, with the aid of the loud speaker, in every important city from San Francisco to New York. Or if chemists have discovered (as Berthelot did some twenty years ago) that sugars need not necessarily be squeezed out of canes and roots, but that they may some day be commercially synthetisized out of familiar gases, the museum will make it possible with the aid

of appropriate models exhibited in that hall to understand the nature of the process and to accept it as perhaps the beginning of an era when at least some of our foods will be produced by juggling atoms in a factory rather than by sowing and reaping. In a word, that special hall will be a place where the news of the laboratory will be concretely expressed in models. In no existing technical museum is such a hall to be found. Science, engineering, and industry are not stagnant. In Chicago their vitality and growth will not be ignored.

The need of an educational institution such as the Museum of Science and Industry is evident. Edison and Westinghouse had to acquire their technical knowledge as best they could at a time when there were few, if any, engineering schools in this country.

Imagine, then, the mental stimulus that the future Edisons and Westinghouses will receive from such an institution as the Museum of Science and Industry. Many a lad is bound to discover that engineering is his true bent. The advanced engineer and the student of industry will likewise profit by an examination of the museum's collections. Science, engineering, and industry are so complex in their interrelationship that it is difficult to grasp the causes and significance of their rapid progress.

Time was when even those who were not themselves artisans had at least an elementary knowledge of the leading arts and crafts. Horses were shod in a smithy with wide-open doors. In this day of the automobile few of the younger generation have ever seen the process of its manufacture. Baking and laundering are now the business of great companies who have reduced them to chemical control. Houses are of necessity still built in the open, but the window frames and posts are delivered ready-made from the mill, so that the carpenter does little sawing and planing and is reduced to the status of an assembler of delivered lumber. Nearly all metal is fashioned in distant mills, and as a consequence only engineers know how rails, girders, and other structural shapes are produced. The factory and the machine have so far usurped the place of the old-time craftsman that nearly all technical processes, from the making of a tin whistle to the building of a locomotive, are now carried on with the aid of massive machines which are mysterious because they are rarely seen by the public. The enormous influence that the scientist has had on industry is but vaguely understood. As for the social effects that follow the introduction of new machines and processes, we are aware of them but we do not grasp their deep significance.

The principles of science are not yet the possession of the many even though the age is essentially scientific; and the effects of scientific research, invention, and industrial progress are felt rather than understood. When Giotto finished a picture all Florence was jubilant and stopped work to celebrate the completion of a masterpiece which was not only a thing of beauty but which expressed the emotions of an art-loving city, all of which was as it should have been, at a time when art was scarcely less important than religion in the life of Italy. Science has usurped the place of art. It is perhaps asking too much that a city declare a holiday and rejoice at the discovery of the X-rays, but it is not too much to expect an intelligent public to discover what X-rays mean to mankind as they find wider and wider application. There is no lack of interest in technology, as the small crowds testify that are fascinated by the stiff but efficient movements of a steam shovel, excavating a huge hole on the site of some future office building. But the people have no opportunity to gratify that interest, no opportunity to survey the technical and social progress of the past and evaluate the status of the present.

And it is the primary purpose of the Museum of Science and Industry founded by Julius Rosenwald to create that opportunity.

Simple Method for Microscopic Slide Preparation

WRITING in the August 30, 1929, issue of *Science*, Edward C. Rosenow, of the Mayo Foundation, Rochester, N. Y., says that the various methods proposed from time to time for locating particular fields of a microscopic slide, although fairly satisfactory for work with low power, are not sufficiently accurate for high-power or oil-immersion work. In all the methods yet proposed, random search is necessary. The following simple method in which random search is eliminated was thought of a number of years ago. It has proved satisfactory in locating organisms difficult of demonstration in stained smears or sections.

The method consists simply of the use of a blank slide, on one side of which is pasted a fairly thin sheet of gummed paper trimmed accurately along the edges of the slide. On either end of this a circle is drawn with a five-cent piece (2.2 cm. in diameter). When a micro-organism or another object of particular importance which is to be photographed or demonstrated later is found, a rough sketch of the high-power or oil-immersion field is drawn in the circle at the left end, and a rough sketch of the low-power field in the circle at the right end of the paper-covered slide. In each case, the object of interest is drawn and its position relative to particularly conspicuous material is indicated. Examples of such conspicuous material are masses of pigment, partitions, margins of section, ganglion cells, round cells, blood vessels, and central canal. The same is done if the slide preparation is a smear instead of a section.

The slide in which a field of special interest has been found is then removed from the mechanical stage, and the paper-covered slide, on which the high-power and low-power sketches have been drawn, is put in its place; it is necessary to make sure that the mechanical stage is not jarred, and that the slide is in the proper position. A dot is then made with pen and ink as nearly as possible in the center of the bright area transmitted from the condenser. The low-power lens is then focused on the dot, and its situation in the field noted. The paper-covered slide is then removed and the situation of the dot in relation to the field is indicated with a small circle around the dot. The paper-covered indicator slide is then numbered to correspond to the slide containing the prized field, and both are filed away together for future reference. If more than one interesting field is found in the same slide, any number of additional indicator slides may be used.

To find the particular field or fields later, the indicator slide is put in place, and the dot brought to the relative position in the low-power field as indicated by the circle surrounding it. The slide containing the object is then put in its place, the low-power field is oriented, and the object of interest brought to the center of the field. The high-power or oil-immersion lens is then turned into position, and the prized object is almost always within the field, and if not it can readily be located.

It is desirable that the fixed end of the mechanical stage of the microscope used for photography or demonstration be the same as the one used when the field was first found, because microscopic slides are usually not of exactly the same length.

Smokeless Combustion in Domestic Heating Plants

Principles Involved in Smoke Elimination—Different Methods of Furnace Firing—Features Which Will Assure Cleanliness, Comfort, Health, and Economy in the Average Home

By VICTOR J. AZBE,[1] ST. LOUIS, MO.

SMOKE abatement is a problem of such long standing that many people are becoming rather tired of it. Repeated attempts have been made to solve it, without, however, arriving at entirely satisfactory results, and as it looks now the problem will stay with us forever unless something rather radical happens. It is strange, nevertheless, that we cannot get rid of something that no one wants, and the probable reason for this is that there are far too many people who think they know all about it and far too few who really know something, and in addition because we temporized with the situation, used old-fashioned poultices when a major operation was the only solution.

First, if we are ever to get anywhere, we must stop talking about "smoke abatement" and begin to talk "smoke elimination." As long as we allow half-way methods we shall have smoke. We must have complete elimination, and whatever that costs will be small compared with the damage done by the smoke. By this the author does not mean that we must stop burning soft coal and substitute smokeless fuels, for he realizes that this, while very desirable, is not entirely practical as yet. He does mean, however, that any equipment that cannot be fired entirely smokelessly with coal should by law be made to use smokeless fuel. Either furnaces should be put in or equipped for smokeless burning of coal, or smokeless fuels should be used. There should be no compromise, the line of demarcation should be sharply defined. And it would be well if smoke "abatement" agencies would change their tactics and adopt rulings of somewhat the following character aiming at "elimination."

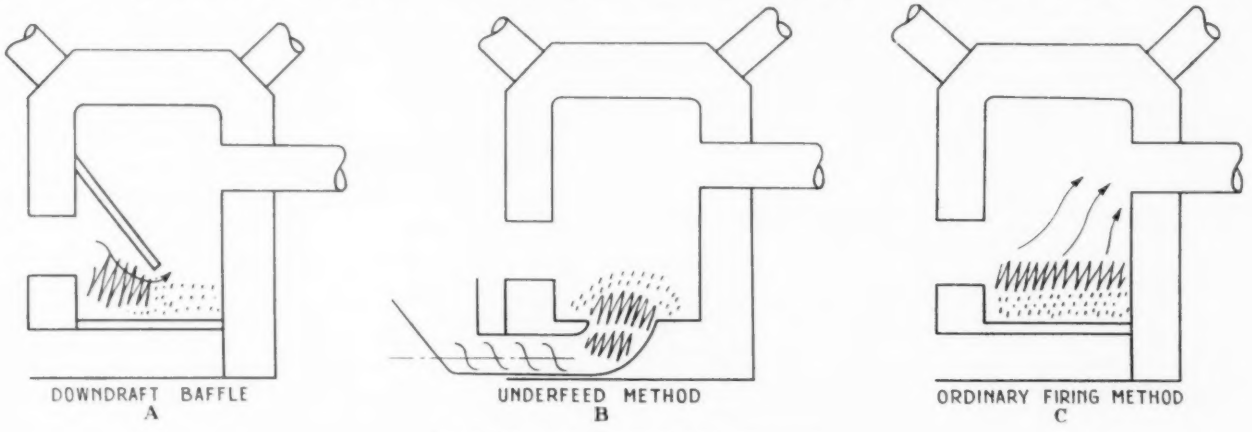

FIG. 1 VARIOUS FURNACE ARRANGEMENTS

PRINCIPLES INVOLVED IN SMOKE ELIMINATION

1 While it is realized that there are furnaces of special make, and firing devices of many kinds that when used properly permit coal to be burned with much less smoke than with ordinary equipment, still it is felt that their use cannot be advocated. Only comparatively foolproof furnaces or devices that are completely smokeless or very nearly so—and this, moreover, in the hands of a careless person—should be allowed, and the firing of these furnaces must be simpler than firing by the ordinary method.

2 The updraft principle of firing coal (when firing is done intermittently) is, from a smoke-abatement standpoint, wrong. Employment of this principle is permissible only when coal is fed to the furnace continuously and in very small quantities by means of automatic methods.

3 When coal is fired intermittently by hand either in a power plant, apartment house, or residence, the furnace arrangement must be such that the flame from the burning coal passes away from the fresh-coal bed and not through it. This means either the downdraft principle shown at *A*, Fig. 1, made possible by the very simple insertion of a baffle in the furnace, or the underfeed principle shown at *B* where coal is fed from below the bed. The ordinary updraft principle as shown at *C* when coal is hand fired cannot be made dependably satisfactory from the smoke-abatement standpoint, and so its use should not be allowed.

4 In view of the foregoing, the various smoke-abatement agencies should recommend—or if they have the power, insist—that larger boilers, such as are located in industrial establishments, should either be equipped with chain-grate stokers or with some type of underfeed stoker. Other types of stokers should be looked upon with suspicion. Hand firing should not be suffered, no matter what the firing method employed. Even with chain-grate and underfeed stokers, though, care should be taken that the furnaces when designed are properly proportioned under the supervision of a qualified engineer, and that with forced-draft stokers, provisions are made for creating over-fire turbulence.

5 Boilers located in schools, apartment houses, or smaller hotels where the larger types of stoker cannot be justified should be equipped with some underfeeding device such as the "Iron Fireman," "Fire King," or other contrivance of the many of this type.

[1] Consulting Engineer. Mem. A.S.M.E. and Chairman of A.S.M.E. Fuels Division and of Research Committee of the Citizens' Smoke Abatement League of St. Louis.

6 In small domestic installations there is the alternative of either using smokeless fuels or equipping the furnace with the above-mentioned downdraft baffle or some stoker of the right kind whenever such becomes available.

7 While every one is in favor of minimizing smoke by special and careful firing such as that by the coking, alternate, or pyramid method or by the installation of some so-called smoke-

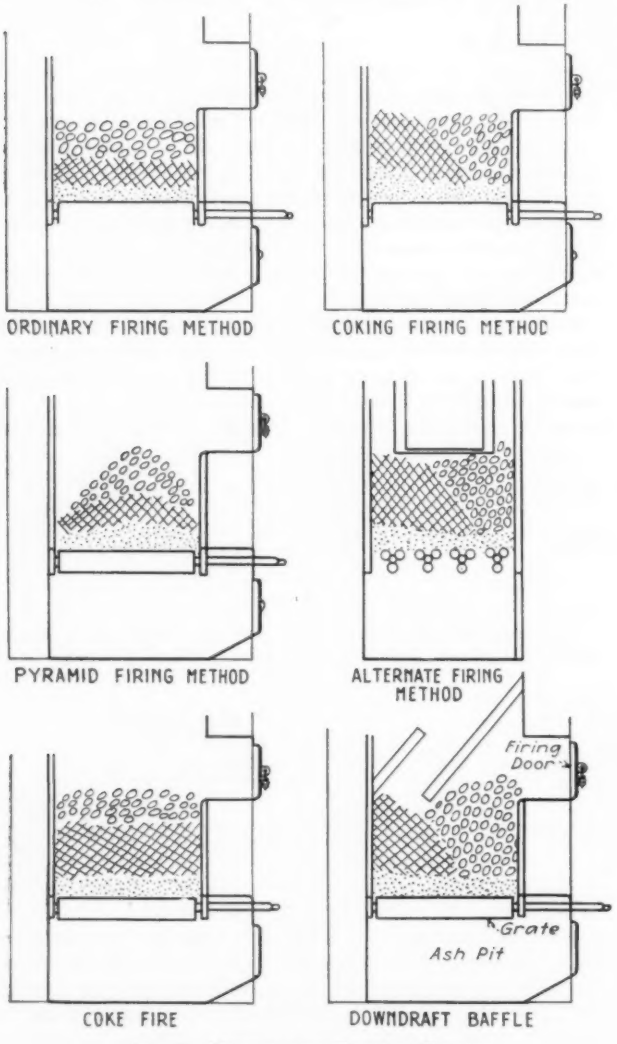

FIG. 2 METHODS OF FURNACE FIRING

eliminating device, it should also be realized that these do not entirely eliminate smoke. The coking method so widely recommended is not practical because the careless person will not use it and because the most careful one will only reduce, but not do away with, the black smoke. As far as smoke-consuming devices are concerned, most of them are of no value whatsoever and are merely dreams of inventors who have no adequate conception of the principles of combustion.

8 Finally, one may say that the objections to smoke are that it is dirty and corrosive, so it should be strongly recommended that in thickly settled communities coal of low sulphur content be burned. Heavy smoke from low-sulphur coal should be considered less objectionable than light smoke from coal having $4^1/_2$ per cent sulphur. The ideal aimed at should be, of course, fuel having less than 1 per cent sulphur and no black smoke. The author realizes that this is rather hard on some coal operators, but one has to be cold blooded when a problem unsuccessfully coped with for hundreds of years stares him in the face.

DIFFERENT METHODS OF FURNACE FIRING

Fig. 2 shows different firing methods that have been tried, namely, ordinary, coking, pyramid, alternate, the coke fire, and the downdraft baffle. Fig. 3 shows the relative amount of smoke produced in a warm-air furnace of standard make fired by these methods under exactly the same conditions and with the same amount of the same coal. It is true that the special methods make less smoke than the ordinary method. The smoke produced with the coking method was only half that produced when

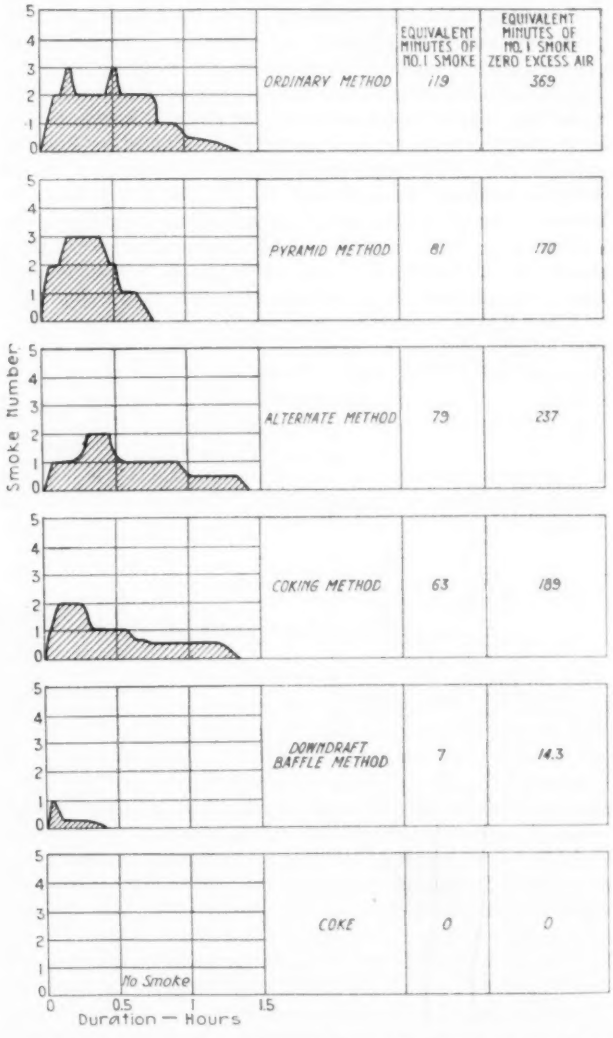
Smoke Number
EQUIVALENT MINUTES OF NO. 1 SMOKE
EQUIVALENT MINUTES OF NO. 1 SMOKE ZERO EXCESS AIR
ORDINARY METHOD 119 369
PYRAMID METHOD 81 170
ALTERNATE METHOD 79 237
COKING METHOD 63 189
DOWNDRAFT BAFFLE METHOD 7 14.3
COKE 0 0
No Smoke
Duration — Hours

FIG. 3 COMPARISON OF VARIOUS FIRING METHODS ON THE BASIS OF SMOKE PRODUCED (50-LB. CHARGE)

the ordinary method was employed. Is a reduction of half sufficient? Certainly not! Particularly since special pains are necessary if this reduction is to be attained. Some people may be induced for a while to push the hot coke back properly, fire green coal in front properly, leave the fire door cracked for a certain length of time and come back later and close the fire door and do this several times a day, but few for a long while.

Fig. 3 also shows how very little smoke was made when this same furnace was equipped at a small cost with a baffle that forced the volatile matter to pass through the hot zone and re-

duced the rate at which the green coal became heated and started to give off gas. Instead of all of the smoke-producing, high-heat-generating volatile matter passing off in half an hour to an hour, it required from two to four hours and longer, so naturally the smoke was infinitesimal, only about a twentieth of that obtained when the firing is of the common variety.

A furnace if correctly designed should not make smoke, should not need be fired more than once a day in mild weather nor oftener than twice a day in cold weather, should not make clinkers except with underfeed stokers, should not need more than seven minutes attention a day in the coldest weather—four in the morning and three in the evening—excepting only the days flues are being cleaned. A properly designed furnace can be easier fired properly than improperly. It will heat the home better and more uniformly with less attention and at a much lower fuel cost. And this all is possible because it has been done. It is the only real solution to the domestic smoke problem with soft coal.

Why do we battle with smoke? Quite evidently mainly because it is dirty, but not all of the dirt in the home is the result of smoke emitted from the chimney. There are other sources of dirt, other causes for discomfort and possible ill-health.

Fig. 4 illustrates advisable measures to secure cleanliness, comfort, health, and economy in the average home. Some of these are as follows:

Features Which Will Assure Cleanliness, Comfort, Health, and Economy in the Average Home

a Proper furnace draft is quite essential, so the stack should be of proper size, properly located, and properly lined. The check damper should be correctly located and the whole furnace should be tight so that air enters only when it is wanted and then either through the fire door, ashpit door, or check damper. These items are emphasized at 1 and 5, Fig. 4.

b Basements are dirty even when coke or anthracite is burned; when ashes are drawn, also when the coal is fired or when it rolls down the pile, a great deal of dust is stirred up. Ordinarily there is an updraft from the basement to the upper floors; the basement door seldom fits tightly, so dirt stirred up in the basement is carried by the air current to the living rooms in rather surprising quantities. Often more dirt enters in this way than with the air from the outside. At 3, Fig. 4, it is emphasized that the basement door should be weather-stripped, at 10 that the coal bin should preferably be closed or dustproof, also that all cracks of any kind between basement and upper floors be made tight. Some warm-air heating installations are arranged to take warm air from the basement, but at 9 it is shown that comparatively clean air from the upper floors should be recirculated through the heating system and not the dirty basement air.

c As shown at 4, every basement should be equipped with a

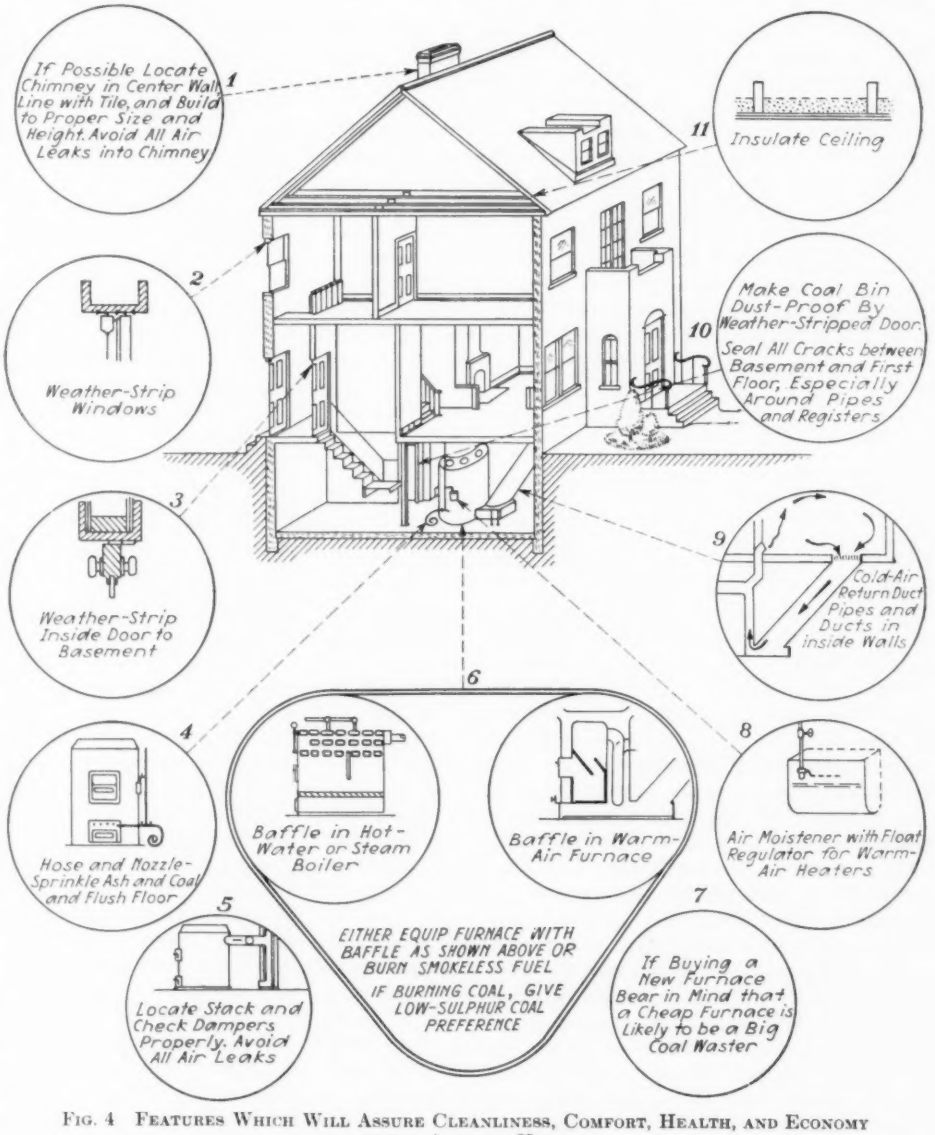
If Possible Locate Chimney in Center Wall Line with Tile, and Build to Proper Size and Height. Avoid All Air Leaks into Chimney
1
Insulate Ceiling
11
2
Weather-Strip Windows
Make Coal Bin Dust-Proof By Weather-Stripped Door. Seal All Cracks between Basement and First Floor, Especially Around Pipes and Registers
10
3
Weather-Strip Inside Door to Basement
9
Cold-Air Return Duct Pipes and Ducts in inside Walls
6
4
Hose and Nozzle-Sprinkle Ash and Coal and Flush Floor
Baffle in Hot-Water or Steam Boiler
Baffle in Warm-Air Furnace
8
Air Moistener with Float Regulator for Warm-Air Heaters
5
Locate Stack and Check Dampers Properly. Avoid All Air Leaks
EITHER EQUIP FURNACE WITH BAFFLE AS SHOWN ABOVE OR BURN SMOKELESS FUEL
IF BURNING COAL, GIVE LOW-SULPHUR COAL PREFERENCE
7
If Buying a New Furnace Bear in Mind that a Cheap Furnace is Likely to be a Big Coal Waster

FIG. 4 FEATURES WHICH WILL ASSURE CLEANLINESS, COMFORT, HEALTH, AND ECONOMY IN THE AVERAGE HOME

water hose connected conveniently near the furnace; the floor should be flushed instead of swept, and the coal sprinkled occasionally. A perforated pipe in the ashpit would make dustless sprinkling of ashes possible before their drawing.

d At 6 it is shown how a downdraft baffle should be installed in a hot-water or steam boiler or in a warm-air furnace.

e Under certain conditions insulation of the ceiling (see 11, Fig. 4) and 2-in. weather stripping of windows and doors are desirable. While ventilation is of course desirable, more than necessary means heat waste, and heat waste means that more fuel is burned and probably more smoke made.

f At 7, Fig. 4, the point is emphasized that when a new furnace is being purchased, a cheap one may most likely prove very uneconomical.

If the coal dealers would show interest, would advise their customers along the foregoing lines and not merely sell them coal, they would be far more popular than they are; also people would not look at the coal pile as upon an evil although a necessary one. The coal men could do much for smoke elimination, but they do not, and unfortunately some of them even obstruct the movement.

However, even the coal man receives entirely too much criticism. He cannot very well help that the best part of his coal if improperly burned becomes a nuisance—the blame for this should be placed on the furnace manufacturer. There are many concerns selling cast iron or sheet steel for furnaces, which, from the combustion engineer's standpoint, often are the crudest devices possible and not even entirely suitable for coke. Then often it will be found that these furnaces are very prominently stamped "A.S.M.E. Standard," which of course means standard of safety and not of efficiency or smokelessness. The furnace manufacturers, even some of the largest ones, appear to devote most of their efforts to bringing out competitive equipment, to creating external attractiveness, and to the selection of alluring names, while internally the whole remains in the nineteenth-century state.

While neither the coal dealers nor the furnace manufacturers fully realize the situation, this could hardly be otherwise since the men in charge of many smoke departments do not know what it is all about. Some chief inspectors lack in technical and others in executive ability, while many are utterly unable to make a convincing speech in public, and some not even in private. To many the job is just a job, and a temporary one at that, as most political jobs are. An unfortunate situation indeed when this still unsolved and very intricate problem is often in the hands of entirely unsuitable personnel.

To be fair, however, we engineers who should know so much have certainly dabbled with the subject in a most discreditable manner. Much of the blame for this can be placed on the engineering school and the engineering society. One has failed to train its students along logical lines, while the other has failed to properly organize the activities of its members.

Strange to say, the only one whom we cannot criticize is the one who makes the smoke—the fireman in the boiler room, the individual, the housewife. We can say that the janitor pouring out No. 5 smoke is careless and ought to be discharged, but truly it is too much to expect that all janitors will be careful and expert. The blame goes to the engineer, furnace manufacturer, smoke inspector, and college professor for not devising equipment that will be foolproof in the hands of the careless janitor.

Physics in Modern Industry

PHYSICS is the source of practically all the general scientific principles on which the industries are built, and these principles constitute its greatest contribution toward material accomplishments. The laws of dynamics, known as Newton's laws, and their corollaries are used in every mechanical design, and without them we should probably have had neither modern physics nor modern industry. The laws of thermodynamics are of universal application and directly useful in the study of all kinds of energy transformations, especially in heat engines. The equations of Maxwell at the basis of the development of radio, and the laws of electrodynamics have led to many results that need not be recounted, and as a simpler and still a very important illustration may be mentioned Ohm's law. These constitute the foundation on which physics and engineering, and therefore also modern industry, are built.

There is a still more important service that physics can give to industry and to society in general. This is connected with the philosophical principles on which all the developments are and must be based. Consider, for instance, the principle of order which we believe applies at least to all macroscopic phenomena of nature. Primitive man did not understand the things that went on around him in the way that we do, and in his efforts to explain to his own satisfaction the things with which he was confronted he peopled nature with a variety of conscious beings, some good and some bad, some friendly and some inimical to his interests. The phenomena of weather, of sickness and of health, of prosperity and of poverty, were all thought to be willed and caused by gods or evil spirits. Primitive man thought himself entirely helpless in all these matters and was governed in many of his actions and many of his thoughts by fear of these supernatural beings and supernatural occurrences.

Science has taught that all the phenomena of nature including even sickness and health take place according to definite laws that are either known or capable of being known by man. When the laws are known, it becomes possible for man to adjust himself to his surroundings in such a way that the elements that were formerly considered dangerous and evil become his servants. His fear of something capricious and something that he was unable to understand and in the nature of things never could understand has disappeared, and in its place is his faith in the orderliness of nature and in his own ability to understand and to regulate the phenomena of nature to his own advantage.

Our manifold contacts with machinery, mechanical and electrical, has taught every one that at least in such matters a result always has an understandable relation to other circumstances, and that the only requisite for satisfactory control of machine and process is sufficient knowledge. So the industrialist has his course of action plainly marked out and he seeks knowledge and more knowledge. The fact that this understanding is a recent acquisition and still not thoroughly a part of us is perhaps illustrated by the fact that when it comes to a matter of our individual physical beings where the machine is not so well understood we are not entirely convinced. At least we are willing to do things to ourselves in the way of eating, drinking, or exposure that we know are harmful. It is probably too much to say that we know, since somehow we have a feeling that we shall escape the consequences of our indiscretions.

The characteristics of modern civilization and our mode of living are largely determined by the products of applied science. Land, water, and air transportation; telegraph, telephone, and radio; the internal-combustion engine that made automobiles and airplanes possible; the electrical industry, from heavy traction and electrically driven ocean liners to the smallest incandescent lamp, are all so much a part of our lives that it is difficult to imagine what it would be like without them. They are all based largely on physics as are also the machines and processes by which they are produced. Industry is busy in the production and maintenance of these and similar devices. It follows that for the future development of industry, physics must take a great if not the principal part in showing the way. By revealing facts of nature, propounding principles, and teaching method, physics must show what can be done and how, and the engineer, who is also a physicist, will work out the details. That, in a word, is the role that physics must play in the industry of the present and of the future. (From article by Dr. L. O. Grondahl in *Science* for Aug. 23, 1929.)

Diesel-Fuel-Oil Specifications

Progress Report of the A.S.M.E. Special Research Committee on Diesel-Fuel-Oil Specifications[1]

A YEAR ago a very lively discussion was held on the subject of Diesel-fuel-oil specifications. At that time it was suggested that a research committee be formed under the auspices of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS to investigate the possibility of establishing standard specifications. Such a committee was subsequently organized by the Society's Research Committee and three sub-committees were appointed, one consisting of representatives of oil-engine manufacturers, one of oil producers, and the third of operators and users of Diesel engines. It has been the duty of these three sub-committees to draft letters to the interested industries requesting information on Diesel fuels from their point of view. These questionnaires were sent to manufacturers of oil engines and producers of oil throughout the world, and the high degree of cooperation received from the various trades indicated that this subject is one of vital interest. The questionnaires asked for particulars on specifications in regard to the adaptation of Diesel operations and limitations on the various essential details of Diesel fuel. With this information in hand, the Committee formulated two suggested specifications, one to cover heavy-duty, slow-speed engines, and the other for light, high-speed units. These specifications were then in turn mailed to the trade with the request that they be commented on and criticised, in order that the Committee might obtain the consensus of opinion of their work to date. The data obtained from the answers to this questionnaire were correlated and the specifications modified to meet the views of the industry.

SUGGESTED SPECIFICATIONS

These suggested specifications as they now stand are given below, together with a brief résumé of each quality and the Committee's reason for accepting the present limits.

	Heavy-duty engines	Light high-speed engines
Viscosity at 100 deg. fahr. (Saybolt Univ.)..	Max. 200 sec.	Min. 45 sec., max. 100
Sulphur.....	Max. 3 per cent by weight	Max. 2 per cent
Conradson.....	Max. 5 per cent	Max. 1 per cent
Ash.....	Max. 0.08 per cent	Max. 0.02 per cent
Flash.....	Min. 150 deg. fahr.	Min. 150 deg. fahr.
Moisture and sediment..	Max. 1 per cent	Max. 0.5 per cent

INFORMATIVE

Specific Gravity or (A.P.I.). Gravity is of no importance as pertains to the burning qualities of an oil. It should be given, however, by the supplier in order that weight per gallon can be computed.

B.t.u. (High value). The approximate value of the B.t.u. should be given by supplier if called for by purchaser, though this can be approximated within one or two per cent for fuels corresponding to the above specifications by means of the following formula:

$$\text{B.t.u.} = 17{,}680 + (60 \times \text{deg. B.})$$

Pour Test (Local importance). In localities where low temperatures are experienced, arrangements for suitable fluidity should be made between purchaser and seller.

Sulphur. It is generally agreed that sulphur is not as serious an offender as has been assumed in the past. Furthermore the crude-oil situation practically forced the users of Diesel engines to go to a higher limit than they had had to accept previously. Consequently the Committee has set the sulphur limit on the heavier grade of fuel at 3 per cent maximum and on the high-speed light unit at 2 per cent maximum; but it must be remembered that the purchase price of the fuel is of major importance. This of course affected the Committee in determining what might be considered as high sulphur limitations.

Viscosity. It is generally agreed that viscosity is one of the most important qualities of the specifications as it determines the fluidity of the oil, and at a given temperature is a fair indication of how readily the product will atomize and how it will affect the injection pump. It is no longer necessary to talk in terms of gravity, which was once believed to be a most essential point in selecting an oil for Diesel engines, as all of the qualities that were once considered represented by gravity are now produced by the viscosity. After considerable discussion, the Committee finally decided to limit the viscosity of No. 1 gravity to 200 seconds, Saybolt Universal, at 100 deg. fahr., while the lighter oil should fall between 45 and 100 seconds, Saybolt Universal, at 100 deg. fahr. These maxima are still considered high by some manufacturers and operators, but to meet all of the requirements of the two Diesel-fuel-oil specifications, it would be necessary to go to these limits.

Conradson Carbon. There are certain Diesel-engine manu-

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[1] The personnel of this committee is as follows:

Henry C. Dinger, Capt., *Chairman*, Head, United States Navy Engineering Experiment Station, Annapolis, Md.

Wiley H. Butler, *Secretary*, Standard Oil Company of New Jersey, New York, N. Y.

H. E. Brelsford, Works Manager, Worthington Pump and Machinery Corporation, Buffalo, N. Y.

R. J. Brogie, Buda Company, Harvey, Ill.

Harte Cooke, Engr., McIntosh & Seymour Corporation, 91 Orchard St., Auburn, N. Y.

Thomas G. Delbridge, Supervisor, Process Division, The Atlantic Refining Co., 3144 Passayunk Ave., Philadelphia, Pa.

Herbert W. Dow, Sales Engineer, Nordberg Manufacturing Company, Milwaukee, Wis.

Lester M. Goldsmith, Consulting Engineer, Atlantic Refining Company, 260 South Broad St., Philadelphia, Pa.

H. C. Hallings, U. S. Representative, Burmeister & Wain, Ltd. (Copenhagen), New York, N. Y.

Charles B. Jahnke, Chief Engineer, Fairbanks, Morse, and Company, Beloit, Wis.

Charles Legrand, Consulting Engineer, Phelps-Dodge Corporation, 741—12th St., Douglas, Ariz.

Kenneth G. MacKenzie, Chief Chemist, Texas Company, New York, N. Y.

John T. McCoy, Assistant Technologist, Tidewater Oil Company, Bayonne, N. J.

Lester G. Metcalf, Assistant Mgr. of Refineries, Union Oil Company of California, 617—7th St., Los Angeles, Calif.

B. E. Meurk, Superintendent Engineer, Isthmian Steamship Lines, 50 Trinity Place, New York, N. Y.

G. H. Michler, Standard Oil Company of New Jersey, 26 Broadway, New York, N. Y.

Ernest Nibbs, Electric Boat Company, Groton, Conn.

Lee Schneitter, Plant Betterment Engineer, Electric Bond and Share Company, 2 Rector St., New York, N. Y.

Harold F. Shepherd, Diesel Engineer, Chief of Diesel Department, Bessemer Gas Engine Co., Grove City, Pa.

George M. Somerville, Atlas-Imperial Diesel Engine Co., Oakland, Calif.

Presented at the Second National Meeting of the A.S.M.E. Oil and Gas Power Division, State College, Pa., June 24–27, 1929, Pennsylvania State College cooperating.

facturers who set great store by the percentage of residue of carbon in a Diesel fuel, while others do not understand the term and are consequently not qualified to express their views on this item of the analysis. The Committee feels that this is a subject upon which considerable research work should be done, as they are not positive that high carbon content, or low, is responsible for unsatisfactory fuel, as reported by some. Consequently the percentages which have been set are open for discussion, but are in line with the type of oil which it has attempted to specify for Diesel fuel. These are 4 per cent maximum for the heavier grade and 1 per cent on the other specification.

Ash. This is undoubtedly the most detrimental quality in any internal-combustion-engine fuel and is responsible for excessive wear and premature engine failures; but it is a question in the mind of the Committee how much of this wear can really be attributed to ash, as incomplete combustion resulting in the deposit of carbon is largely responsible for this condition. Tentatively, 0.08 and 0.02 per cent maximum have been accepted as the upper limits for ash in the two Diesel fuels.

Water and Sediment. This point came in for very little discussion and it was generally conceded, and has been accepted by the majority of operators and oil companies, that a 1 per cent maximum in Diesel fuel is within practical limits.

Flash. From the point of view of insurance regulations, a legal stipulation of 150 deg. minimum flash was accepted.

Informative Data. Gravity is not mentioned in the specifications, as it was previously stated to be of minor importance; but the Committee has specified that the seller should advise the buyer of the specific gravity or A.P.I. degrees of the oil, in order that the engine operator may be able to determine the weight per gallon and estimate the calorific value. Nor has the Committee specified the B.t.u. content, as any of the oils meeting the above specifications will be well within 18,500 B.t.u. per lb. as a minimum, and consequently satisfactory for internal-combustion-engine operation. It was thought advisable to consider the pour test as of local importance, and the specification states that in localities where low temperatures are experienced, arrangements for suitable fluidities should be made between the purchaser and the seller.

Distillation Test. The boiling-point range of Diesel fuel usually extends to temperatures high enough to result in considerable decomposition, or cracking, when an attempt is made to distil these oils at atmospheric pressure. Therefore a distillation test carried out under that condition has little value in most cases as an indication of Diesel-fuel quality. Misleading conclusions are likely to be drawn from results of such atmospheric-pressure distillations. While the Committee recognizes that distillation under high vacuum is a splendid research tool, nevertheless it feels that the difficulties of operation together with the complicated nature of the operation precludes the possibility of this method's being used in routine testing.

Heavy Diesel Fuel

There is a product universally distributed throughout the world which is commonly known as "Bunker C Fuel Oil," which product can be obtained in practically any large port and is used by oil-burning steamers in large quantities. The Committee is considering the advisability of formulating a third specification which would modify the broad limits now accepted for Bunker C and specify that such an oil where obtainable would be satisfactory for the operation of certain large, heavy-duty, slow-speed units. It must be remembered, though, that it would be difficult and costly for bunkering stations to carry two grades of boiler oil, one for steamships and the other modified to meet the Diesel specifications, and this specification would be primarily an indication to Diesel-engine operators that where the heavier grade of oil does fall within the Diesel limits it might be used for such a purpose.

Advantages of Standardization

There has in the past been some lack of cooperation and understanding between the oil industries, Diesel-engine manufacturers, and the operators of oil engines, largely due to misunderstanding of the requirements and limitations of all parties concerned. The Diesel-engine manufacturers have in the past set very close and exacting specifications, which have been difficult or impossible for the oil companies to meet. Engine operators have demanded such oils and they have been under the impression that unless they followed the suggestions of the builders of their engines they would experience considerable trouble and be confronted with large maintenance bills. Some oil companies have not taken the proper interest in the Diesel and have occasionally supplied products of which they wished to dispose, irrespective of their suitability for Diesel operation. If sensible and useful standard specifications can be established and accepted by the three interested divisions, a great deal of trouble experienced in the past will be automatically eliminated, as each side of the industry will be assured of products which can be supplied conveniently and which can be depended upon for satisfactory operation. Furthermore, a standard product could be produced at a somewhat lower price than that at which Diesel fuels are today marketed. The differential between the boiler oils and Diesel fuels could be materially reduced, which should place the oil engine back in its place of economic superiority, whence it is being removed due to high-pressure steam installations and exceedingly low-priced boiler oil. Furthermore a tremendous burden would be taken off the shoulders of the oil industry, namely, that of attempting to maintain unnecessary tankage and distribution facilities at ports other than refinery centers, all of which has assisted in maintaining relatively high prices for Diesel fuel. Considering the specifications for light, high-speed engines, it is altogether possible that the same grade of oil can be used for domestic heating, which would insure the manufacturers of engines for mobile equipment and rural installations a general distribution of a fuel throughout the entire United States.

Foreign Matter

There are numerous things in operating Diesel engines which cause considerable trouble and which it is impossible to eliminate when developing specifications. These troubles can be largely corrected by the operators, but it is generally the case that the oil is blamed for most of the evils encountered. Cylinder-liner wear can result in foul air being drawn into the cylinders. Analyses of air in various industrial centers show astounding percentages of dust and dirt of various natures. In such cases if operators would install air filters to prevent this material from depositing on the lubricated surface of the liners, large maintenance bills might be avoided. Again, if more care were taken in maintaining clean tankage, various unnecessary shutdowns due to failure of injection-pump and atomizer valves might be eliminated; then, too, if centrifuge equipment or the proper type of filters were installed which would eliminate the dirt and foreign matter before it reached the engine, there would be less complaint of dirty fuels being delivered to Diesel engines. One of the sources of trouble in Diesel operation is the improper blending of oils in refineries as well as at the installation. Products of widely varying viscosities will often stratify when improperly blended, and will sometimes deposit large quantities of granular and flaky carbon in the tanks, line pumps, and injection nozzles. All these are matters which are somewhat

beyond the facilities of the Committee to investigate, but it is believed that a little education, perseverance, and care on the part of oil producers and engine operators would eliminate many of the unfortunate experiences which lead to contamination of certain oils which otherwise would be perfectly satisfactory for Diesel operation. The Committee welcomes pertinent information on these subjects from those concerned in order that informative data may be embodied in future reports of the Committee for the benefit of all concerned.

RESEARCH

This Committee was organized as a Research Committee to determine the possibility of establishing practical, economical, commercial Diesel-fuel-oil specifications. Due to a widely diversified personnel, organized research is difficult but there are certain members of the committee who are in a position to test oils in Diesel engines on the block, while others have at their disposai research laboratories in which inspections and analyses of unsatisfactory fuels may be conducted. The Committee therefore asks that interested parties who experience difficulties with the fuels that they consider unsatisfactory for Diesel operation, send it samples of such oils in order that it may determine the cause or causes of unsatisfactory operation. Some work has been done along this line and certain points have come up for discussion which if solved will be a tremendous aid to the interested industries. For instance, there is a product among the Diesel fuels that from all appearance is an oil beyond reproach for Diesel operation, but it functions very peculiarly in an internal-combustion engine, producing a cloudy exhaust and a very pronounced combustion knock, is very hard starting from cold in some instances, and sparks are even emitted from the exhaust. The Committee would welcome discussion on these conditions and the receipt of such oils for experimental work.

CONCLUSION

While the foregoing has been presented as a Progress Report of the A.S.M.E. Special Research Committee on Diesel-Fuel-Oil Specifications, it should be kept in mind that this Committee has not the authority to establish standard specifications. It feels, however, that its work has reached the point where cooperation with a committee organized to develop American Standard Specifications is desirable. Such a recommendation has accordingly been made to the Council of the Society, which in turn has requested the American Standards Association to organize a sectional committee for that purpose.

It is apparent that there is still need for research in this field, and the Special Research Committee intends to continue actively working for the purpose of coordinating and correlating information which will most likely be developed by industry in proving the merits of the proposed American Standard Specification.

The Committee requests free discussion and criticism of the report presented herewith, as it is only through the constructive criticism of all interested persons that a satisfactory specification for Diesel fuel oil can be established.

Discussion

HENRY C. DINGER.[2] It seems desirable in connection with the future work of the committee, to develop and assemble some information as to the character of the fuel oil that will be available for the next ten years. Such information will be of interest especially to the engine designer. If this information can be developed, it will point development and design in the proper direction; since the measure of success that the Diesel engine will achieve is largely dependent on how well it can perform on the fuel that is commercially available at a price at which it can compete successfully with other means of power generation.

Another field is to develop definite information as to the cause for unsatisfactory operation that is really due to the fuel or to the method of operation. These causes of bad operation can be located if, when they occur, the users will cooperate with the committee and send in some definite, concise, clear information as to what has happened, and also send in some samples of fuel used to the laboratories that are available for the work of this committee.

H. E. BRELSFORD.[3] One of the things that is comparatively new in the viewpoint of oil is the so-called Conradson carbon equivalent. It is a method of determining carbon in the form of oil that is not ordinarily available for combustion.

It has been found that up to about two per cent Conradson there is but slight effect on engine performance. Ordinarily an engine cannot be tested much more accurately than two per cent or probably it would be found that the effect of Conradson starts from zero. If an engine manufacturer guarantees engine performance without regard to carbon as determined by the Conradson method, he will probably get into trouble unless his guarantees include such tolerance as to give him necessary leeway.

It behooves all the manufacturers to make their guarantees such that under the widely varying oil characteristics that exist even with this standard specification, they will meet no difficulties which will cause customers to feel that the quality of oils is so doubtful and variable as to make it impossible to regard anything as exactly a standard.

CHARLES HASKELL.[4] The committee has worked on perhaps a dozen different methods trying to get some laboratory tests which would indicate when an oil will give a smoky exhaust or a lot of carbon in the cylinders. Conradson carbon is a distillation of the oil out of the air, but open to the atmosphere.

LEE SCHNEITTER.[5] In some foreign countries, operators of Diesel engines are forced to use the cheapest kind of low-grade oils to produce cheap power. In Cuba some engines have been operated for six or seven years on low-grade crude oils which come from the Mexican fields. There has been a lot of carbon-residue trouble and bad deposits on pistons and exhaust ports. These were two-cycle engines. Maintenance costs have been unreasonably high and excessive liner wear has occurred. Cylinder liners wear out in about two and one-half years, but the difference between the light-oil cost and the heavy-oil cost is so great that it is cheaper to replace liners every two or two and one-half years than pay the higher fuel cost. If a low-priced oil of lighter viscosity and lower ash and carbon content could be obtained, it would be preferred. The Diesel-engine user is interested in getting a cheap oil and getting a good Diesel engine, and with those two qualifications met, it is assumed that he can produce cheap power. That is what all are interested in.

J. B. FRAUNFELDER.[6] In developing a new type of two-cycle double-acting engine for a company which produces oil, operates Diesel engines, builds Diesel engines, and builds its own ships, it has been necessary to use oil from 35 deg. A.P.I. down to 18½ deg. A.P.I. This two-cycle double-acting engine is a port-scavenging engine, has no inlet or outlet valves, and has no

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[4] Texas Company, New York, N. Y.

[5] Plant Betterment Engineer, Electric Bond and Share Co., New York, N. Y. Mem. A.S.M.E.

[6] Sun Shipbuilding & Dry Dock Co., Chester, Pa.

exhaust-valve troubles. At the present time 22½ deg. A.P.I. is being used. The only changes made in the engine were the changing of the type and number of spray plates in the fuel valves.

This engine has run over a thousand miles on these various fuels, and no trouble has resulted with any of them except with the 35-A.P.I. fuel, which could not be kept in the pump.

This company operates its own ships and the auxiliary engines use the same fuel as the big engines to do away with the necessity of carrying two kinds of fuel in the tankers or the other ships.

E. NIBBS.[7] The company with which the writer is connected has had no trouble with exhaust valves, but did get a very great deposit of light, fluffy carbon, the actual cause of which is unknown. There seems to be a characteristic peculiar to some fuels which in combination with special alloy steel used for exhaust valves causes a kind of pitting. The valve is not eroded or burnt, but looks as though a very thin flake of carbon had been deposited on the seat and hammered in.

The operator who knows nothing much about this peculiar characteristic imagines he has a leaky valve when he inspects it. He grinds it in and makes a perfect seat, looks at it a month later, finds it exactly the same, viz., apparently pitted; curses the steel, the oil, and the engine builder, and grinds it in again. An accident at one time made it necessary to take out a valve twenty-four hours after it had been ground to a perfect seat. It was found to be pitted exactly as it was after it had run a couple of months. It was decided that as the main function of the valve is to hold compression, the appearance of pitting is now disregarded as long as there is proper compression pressure.

JULIUS KUTTNER.[8] The new specifications are stressing viscosity a little more than has been done in the past, and some attention is being given to the Conradson test, and the possibility of making that a basis of predicting what a fuel oil will do in an engine on the basis of its specification. However, nothing has been added to the list of things to specify, nor is a measurement of quantity given which will tell what the oil is going to do when it burns in an engine. For that reason one must go back to chemical science, to physical science, and possibly even to the very difficult molecular theories of combustion, before there will be any really noteworthy progress in the direction of standardization.

The chemical nature of the residues is of interest, and nothing can be predicted about them until the combustion process can be traced more accurately than is now done.

As an intermediate step which might be taken before chemical science catches up enough with the problem, it might be well to see if some other fuel-oil property can be found besides those which are ordinarily specified and which have been worked with so long without noticeable results.

Viscosity is a good thing to specify. The Conradson number, while opinions on it are not entirely unanimous, probably is good also, but those two things together still do not tell everything that should be known.

If the use of a gum test for Diesel fuel oils might lead to results, it should be proved or disproved. If it is no good, it should be dropped and, on the other hand, if it does add to the true picture of the oil as a Diesel fuel it should be cultivated. The reason why the gum test might offer a solution of the difficulty in so far as really specifying performance is concerned is that a large percentage of the troubles in Diesel engines is caused by a cementing together of moving parts. Sticking of valves and rings is due to a cementing action which cannot be completely explained on the basis of carbon formation alone. Amorphous carbon and lubricating oil, or unburned lubricating oil, will not form a cementing paste such as is found in engines whose operation has been impaired by unsuitable fuel.

Examination of a Diesel engine that has been ruined by bad fuel or put in serious operating condition by unsuitable fuel will show that the entire trouble manifests itself primarily in two items, stuck valves and stuck rings. The sticking of the rings causes blow-by, ruins the lubrication of the cylinder, fouls up the lubricating oil in the circulatory system, damages bearings, and leads to a deterioration of the entire engine. If sticking can be prevented and compression held up, the fuel oil ought not to do any harm provided it contains no abrasives and no water. That is why a specification which correctly reflects this property should be of more value than all the other specifications put together.

WILEY H. BUTLER.[9] This is merely a suggested specification. Oil companies cannot sell an oil not accepted as standard. They will go along with present methods, until this is accepted as a standard and has been proved a standard oil. Various oils meeting these specifications, and meeting the maxima not coming within the specifications will be sent out to various installations, not only to engine builders to test on the block, but to installations that are actually in operation, and they will be tested very carefully. There will be a code of test established by this committee and the information will be correlated, and it will be decided whether those oils can be operated in various types of engines, and until that time it can not be called a successful standard Diesel fuel. When that is done, and the standard groups place their stamp of approval on it, then it will become a standard Diesel fuel, and can be purchased and will be made by the oil companies.

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[8] Editor, *Oil Engine Power*, New York, N. Y. Mem. A.S.M.E.

[9] Standard Oil Company of New Jersey, New York, N. Y.

Malleable Stainless Steel

THE new malleable stainless steel "maxilvry," produced by Edgar Allen & Co., Ltd., Sheffield, is more like the type used for stamping and pressing but takes a higher luster when polished. It is also more resistant to corrosion, etc., than the ordinary type of stainless iron.

This stainless malleable steel is an alloy of iron with a high percentage of nickel and chromium and a small copper content. It is manufactured in a Heroult electric-arc furnace and great care is taken in controlling the composition and casting temperature so as to obtain a product of uniform composition and properties. It is generally used for deep stamping and cold pressing as its great ductility and malleable character render it specially suitable for this purpose. It is non-magnetic under all conditions and can be hot-pressed if desired.

Maxilvry steel should be softened by heat at 1150 deg. cent. and cooled in air for cold working. It can be riveted cold when the size is not too great and hot-riveted above the point.

With regard to machining, little difficulty is experienced in machining this steel if the tool edge is kept in good condition; if the tool is allowed to become dull and rubbed the surface will work-harden and difficulty will be experienced in further machining. The cutting angles of the tools should be very similar to those used for mild steel, but the speed should be considerably reduced.

Sawing presents considerable difficulty and annealing does not greatly improve this. More economical results are usually obtained by parting off the steel in a parting machine.

This special steel is particularly suitable for work of an ornamental nature that necessitates a fine polish; boat fittings, curbs, dental mirrors, etc.—*British Machine Tool Engineering*, vol. 5, no. 58, July-August, 1929, p. 270.

SURVEY OF ENGINEERING PROGRESS

A Review of Attainment in Mechanical Engineering and Related Fields

The i–x Diagram for Steam-Air Mixtures

IN 1923 (*Zeitschrift des Vereines deutscher Ingenieure*, vol. 67, p. 869, et seq.) the author of the present paper gave a graphical method of solving many of the problems dealing with steam-air mixtures. Since then it has been found that the diagram given in that article was essentially correct and the present article represents an extension of the method presented previously.

The diagram (Fig. 1) is good for changes of state taking place at constant total pressure. It is applicable, of course, not only to mixtures of water vapor and air, but likewise to mixtures of other gases and vapors, for example, air and oil vapors. The present article, however, deals specifically with water-vapor and air mixtures. As only small partial pressures are used in the majority of technical applications of such mixtures, the laws of perfect gases have been applied both for the air and steam and where the temperatures are not unusually high the specific heats of both fluids were assumed to be constant.

The following notation has been used:

p = partial pressure of the steam

p' = the saturation pressure of the steam corresponding to a given temperature t

p_0 = total pressure

$p_0 - p$ = partial pressure of the air or gas

x = the abscissa on the diagram; it represents the quantity relation of steam to air in kg./kg., which means the amount of water added to 1 kg. of air. Usually $x = \frac{M_D}{M_L} \times \frac{p}{p_0 - p}$ where M_D and M_L are respectively the molecular weights of the steam and air. Measuring x in kg./kg. is common. It would have been simpler to express this quantity in mol/mol, in which case $x = \frac{p}{p_0 - p}$

For water-vapor and air mixtures $x = 0.622 \frac{p}{p_0 - p}$.

x' is the maximum possible value of water-vapor content for $p = p'$. Hence $x' = 0.622 \frac{p'}{p_0 - p'}$.

L is the air content in the mixture in kilograms so that the total weight of the mixture is $L(1 + x)$.

c_L and c_D are respectively the specific heats of air and steam at constant pressure. In the present paper the following values have been adopted: $c_L = 0.24$ and $c_D = 0.46$.

i is the ordinate in the present diagram and represents the heat content or enthalpy of 1 kg. of air plus x kilograms of steam, so that $i = 0.24\,t + x\,(0.46\,t + 595)$ where 595 is the heat of evaporation of water at 0 deg. cent.

i' is the heat content of air saturated with water vapor, hence $i' = 0.24\,t + x'\,(0.46\,t + 595)$. For a given total pressure, i' and x' are functions of the temperature solely.

The i–x Diagram (Fig. 1)

There is an advantage in using acute-angle coordinates for the i–x diagram, because it permits a better utilization of the field of vision and gives a clearer view of the important groups of curves. In accordance with the above formula for the heat content, the isotherms have to be straight lines.

It is notable that if the angle of coordinates is selected with respect to the vertical position of the i axis in the way it is done in the present diagram, then the 0-deg. isotherm is horizontal.

In a way one has, then, side by side with the main diagram a second rectangular system in which the values of x are abscissas and the ordinates are $i_0 = (0.24 + 0.46\,x)\,t$, i.e., heat content of steam at 0 deg. cent., this being very convenient for plotting the diagram. It is, of course, not necessary in all cases to employ the method of determination of the angle of coordinates given here.

Boundary Curve

The isotherms are independent of the total pressure selected and this pressure appears only when the saturation line or boundary curve is plotted. The boundary curve has as its coordinates i' and x', and is plotted by determining on the isotherms the points having x' for abscissas. The usual way is to plot the boundary curve for some average barometric reading, but it is possible to plot boundary curves for different barometric readings. Under certain conditions, pressures differing considerably from atmospheric may have to be provided for, as, for example, when it is desired to cover the case of vacuum drying. A curve may be plotted for temperatures below 0 deg. cent., as, for example, the boundary curve corresponding to vapor pressure over ice.

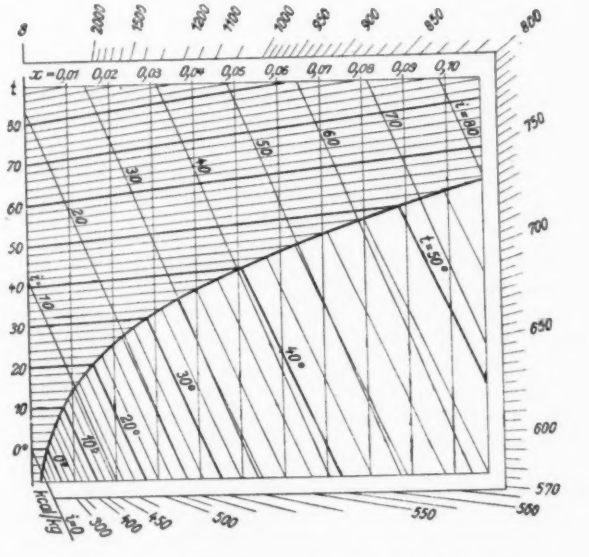

FIG. 1 THE i–x DIAGRAM FOR STEAM-AIR MIXTURES

(The vertical axis of ordinates $x = 0$ contains the states of dry air. The point corresponding to 0 deg. fahr. is the origin of the ordinates. From this starts the axis of abscissas $i = 0$, and to it refer the markings of the marginal scale. The boundary curve for saturated air is plotted for a pressure of 1 atmos. and divides the unsaturated region, above, from the region of fog, below. In both regions the isotherms are plotted for every two degrees.)

The boundary curve for undercooled water is plotted in dotted lines in Fig. 2 in the original article.

In his previous paper the author plotted on his diagram a line of "equal relative humidity." He does not do it here, because this magnitude which he calls $\varphi = p/p'$ represents the ratio of the vapor actually present in a given space to the maximum amount of vapor that may be present there at a given temperature. It is simpler to plot instead the "degree of saturation" of the air ψ determined by the ratio x/x'. Lines of constant de-

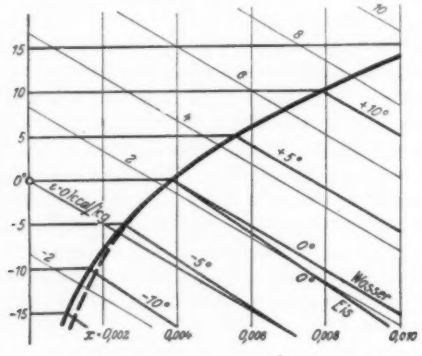

FIG. 2 THE i–x DIAGRAM FOR THE REGION IN THE NEIGHBORHOOD OF THE FREEZING POINT

gree of saturation are plotted in the diagram simply by dividing the isotherms between the axis of ordinates and the boundary curve into equal parts and connecting corresponding points.

For temperatures higher than the saturation temperature corresponding to the given total pressure, ψ becomes equal to infinity, which means that any amount of steam can be added to the air. The ψ lines run asymptotically to the given isotherm. φ and ψ are connected by the following relation

$$\frac{\psi}{\varphi} = \frac{p_0 - p'}{p_0 - p}$$

It follows from this relation that at ordinary temperatures of outdoor air, the difference between the two magnitudes in question is a very slight one, and hence the information available from meteorological observations over the relative humidity φ may apply to the degree of saturation, ψ, and the determination of the degree of saturation for the i–x diagram is so simple that it was considered unnecessary to plot the ψ lines in the diagram.

Moreover, φ and ψ give only a one-sided view of the degree of saturation of air and merely indicate how much more moisture the air can take up as long as its temperature is not changed. In practice, it is often of greater importance to note the degree of saturation under the assumption that during the passage to saturation no more heat is supplied. To do this it becomes necessary to compare x with the value of x' at constant heat content or at the limit of cooling. (More about this will be said later.)

MARGINAL SCALE

In working out many problems it is desirable to be able to determine quickly the direction of the change of state of the air, $\frac{di}{dx}$, or the line connecting the two states, $\frac{i_2 - i_1}{x_2 - x_1}$, or else plot a straight line having a given direction on the diagram. To facilitate this a marginal scale (Fig. 1) has been introduced and gives, for various values of di/dx, corresponding lines starting from the origin of the coordinates. According to the proposition made by Hirsch, a scale made of transparent paper can be used instead.

VOLUME AND SPECIFIC VOLUME

The volume V of a steam-air mixture containing 1 kg. of air and the specific volume v, as well as the specific weight $1/v$, are calculated from the following formulas:

$$V = \frac{47.1\ (0.622 + x)\ T}{p_0}$$

$$v = \frac{47.1\ (0.622 + x)\ T}{p_0(1 + x)}$$

Here T is the absolute temperature and p_0 the total pressure in kg. per sq. m. Grubenmann has shown that both the lines V = constant and v = constant give nearly parallel straight lines in the i–x diagram, so that even without plotting them it is possible from the marginal scale to determine without trouble in what direction V and v vary whenever the state varies. The following are formulas for the exact values of direction of these lines:

$$\left(\frac{di}{dx}\right)_V = 470 + \frac{0.046\ T}{0.622 + x}$$

$$\left(\frac{di}{dx}\right)_v = 470 + \left(0.46 + \frac{0.046}{0.622 + x} - \frac{0.22}{1 + x}\right) T$$

REGION OF FOG

When in any case of change of state the boundary curve is exceeded, this produces a separation of liquid or ice out of the saturated air. The region below the boundary curve represents therefore a mixture of gas, vapor, and liquid, or ice particles, and

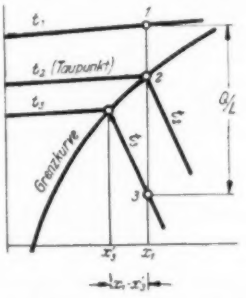

FIG. 3 CHANGES OF STATE AT CONSTANT WATER CONTENT x

(Line 1–2–3 represents a change of state in the case of moist air, assuming constant water content. At point 2 (dewpoint) the boundary curve is exceeded. In the range 2–3, separation of water takes place. The distance 1–3 shows the heat which has been taken away, while $x - x'_3$ shows the amount of water separated. The basis of the diagram is 1 kg. of air. *Taupunkt* = dewpoint; *Grenzkurve* = boundary curve.)

each point corresponds to a clearly determined state. Of course, it is necessary to assume here that the entire mass is in a state of thermal equilibrium. This will be particularly possible if the liquid flows in the saturated air in a state of very fine subdivision (fog). It will then be necessary to carry the isotherms beyond the boundary curve, and these have, of course, an entirely different shape in the fog region. Let x be the total mass of the second material added to a unit of mass of the gas. Of this, at a given temperature, the amount x' is in a state of vapor and the rest $x - x'$ is either fluid or solid. For the case of water vapor and air mixtures the heat content of the total mixture is as follows:

$$i = i' + (x - x')\ t$$

Since x' and i' depend only on temperature, the isotherms in the region of fog will be also straight lines, but their inclination is given by $\left(\frac{di}{dx}\right)_t = t$ (Fig. 1).

Furthermore, if the temperature is not very high, the isotherms are approximately parallel to the lines $i' =$ constant.

The author discusses further the heat content in this region, and then proceeds to the discussion of changes of state taking place while the water content x remains constant. The point denoting the state moves along the vertical line in the i–x diagram as shown in Fig. 3 in the original article, and its point of intersection with the boundary curve denotes the point of melting. The water content x of air can be changed by adding to a given amount of air a certain other amount containing a different proportion of water, or adding to the air, water vapor or water

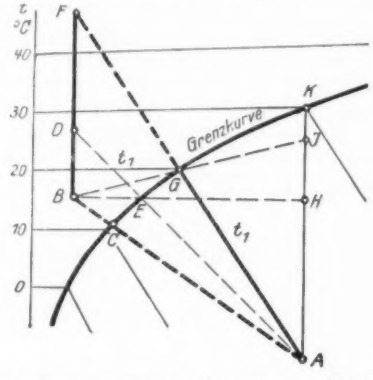

FIG. 4 ELIMINATION OF FOG BY ADDITION OF UNSATURATED AIR AND ADDITION OF HEAT
(*Grenzkurve* = boundary curve.)

itself, and finally by precipitating some of the water vapor from the air and taking it away. These processes may be accompanied by addition or subtraction of heat. It is important to note that, in the final result, it is entirely immaterial whether the heat has been changed before, or after, or during the mixing process, or whether it has been added to one or the other of the constituents of the mixture.

MIXTURE OF TWO AMOUNTS OF AIR DIFFERING FROM EACH OTHER IN THEIR STATE

Let it be assumed that an amount of air $L\ (1 + x_1)$ of temperature t_1 is added to an amount of air $L_2\ (1 + x_2)$ of temperature t_2 without any addition of outside heat.

It will be assumed that $1 + x_1$ kg. of mixture having a state 1 is used to start with and that to this is gradually added more and more air of state 2. In such a case x as well as i will increase in proportion to the air conditions, i.e., the state of air varies from the state 1 in a straight line on the i–x diagram, and since the state 2 must be ultimately reached if the addition of "state 2" air goes on infinitely, all the states of mixture of the two kinds of air must lie on the straight line connecting the states 1 and 2. The abscissas x_m of the state of mixture is given by the following equation:

$$x_m = \frac{L_1 x_1 + L_2 x_2}{L_1 + L_2}$$

The temperature of the mixture can be read directly from the diagram and it does not matter in which of the two ranges of the diagram points 1 and 2 are located. If the state of mixture happens to be in the unsaturated range, the temperature of the mixture can be calculated as well; if, however, it should happen to be in the range of fogs, then only a graphic determination is possible. If two saturated masses of air are mixed, fog is always formed and its amount can be directly read off from the diagram. With a state 1 in the range of fog and unsaturated air of state 2, it is easy, for example, to answer the question as to how much of the latter air has to be added to the air containing fog in order to destroy the fog. All that is necessary is to connect the two states by a straight line and the intersection of this line with the boundary curve gives the value of x_m which is the maximum that need be available, and from this the ratio of mixtures is found to be

$$\frac{L_1}{L_2} = \frac{x_m - x_2}{x_1 - x_m}$$

If the mixture of two masses of air is accompanied by the addition or removal of an amount of heat Q, a terminal state will be found by adding or subtracting the amount Q/L_1 or Q/L_2 in the vertical direction in the states 1 and 2, and then handling the mixture as before.

In Fig. 4, point A is in a definite state of fog 1, while point B represents unsaturated air of state 2; it may now be shown how by the mixture of the two the fog is made to disappear. In order to attain this, the terminal state must at least be located on the boundary curve. If no heat is added the amount of air that must be added to 1 kg. of foggy air is

$$\frac{L_2}{L_1} = \frac{\overline{AC}}{\overline{BC}}$$

If, however, we add heat to the air before mixing, less air will be required. By adding an amount of heat $Q/L_2 = \overline{BD}$, a state D will be reached, and L_2/L_1 is now equal to $\frac{\overline{AE}}{\overline{DE}}$. If, in the action of destruction of the fog, the initial temperature of the foggy air t_1 is not changed, it is necessary to transfer the air to the state F by the addition of an amount of heat $Q/Q_2 = \overline{BF}$, so that after the mixture with the foggy air state G is reached. The amounts of heat $\overline{BD}$ and $\overline{BF}$ relate to one kilogram of air having the initial state 2 (point B). In order, however, to make them comparable to each other, it is necessary to have them related to 1 kg. of foggy air. By drawing broken lines BH and BJ through E and G, we obtain $Q/L_1 = \overline{AH}$, or $Q/L_1 = \overline{AJ}$. Fog can be eliminated without adding any air by means of an addition of heat $Q/L_1 = \overline{AK}$. It must be noticed in this connection that the amount of heat $\overline{AK}$ does not have to be larger than that supplied in the way of an air mixture and it is easy to see that from Fig. 4 by imagining that point B is located lower than it actually is. (Paper by Richard Mollier of Dresden, initially published in the memorial volume issued on the occasion of the 70th anniversary of A. Stodola; reprinted in and abstracted from *Zeitschrift des Vereines deutscher Ingenieure*, vol. 73, no. 29, July 20, 1929, pp. 1009–1013, *pA*. Only the first part is here abstracted.)

Short Abstracts of the Month

AERONAUTICS

Aircraft Diesel-Engine Possibilities

THE author considers the matter from the point of view of efficiency (both thermodynamic and combustion), power output, and reduction of engine weight.

In practice the use of partial combustion at constant volume results in a greater gain in economy than simple theory indicates, since the higher temperatures involved, coupled with the slightly increased time available for combustion, result in a substantial reduction in fuel consumption. There is, however, a limit to the amount of the constant-volume portion of the cycle, and this depends to some extent upon the engine speed. It is estimated that at 800 r.p.m. there is a little gain exceeding 950 lb. per sq. in.

maximum pressure, while at 1000 r.p.m., 1100 and 1200 lb. per sq. in. represent approximately the maximum economical figures. The most suitable maximum pressures at which all around economy and reliability over long periods can be obtained are given in the original article.

Until improvements are made in injection and combustion control, the maximum power output will be much less than that theoretically possible. As practiced today there is usually an excess of air of the order of 30 per cent. By the addition of extra fuel it is possible to cause some of this air to take part in the combustion processes, but only at the expense of a rather rapid increase in fuel consumption. The author does not offer any method of solving this problem.

One of the technical difficulties that have to be overcome in the development of the Diesel engine, the limitation of its power output, is the most important and at present it is necessary to install a slightly larger engine for a given horsepower. The usual rating of the four-cycle oil engine is of the order of 100 lb. per sq. in. in brake m.e.p. as against an average of 130 to 140 lb. per sq. in. for a gasoline engine.

The best interests of the industry will be served by keeping the maximum output of the four-stroke oil engine within 110 lb. per sq. in. until greater experience is obtained, which means that the oil engine will be rated at 85 to 90 per cent of the power of a corresponding gasoline engine running at the same speed. The maximum output of the two-stroke oil engine should be limited to 100 lb. per sq. in.

Of the factors limiting the power output from any combustion engine, the item of mechanical losses is greater in the oil engine than in the gasoline engine. Piston speeds of the former now compare favorably with those of the gasoline engine. There is no reason why the aircraft Diesel should not employ the two-stroke principle although this has not been done as a rule so far.

A four-stroke oil engine weighs approximately 10 per cent more than a gasoline engine of the same type and size, and it should be possible to design a two-stroke engine for a further addition of, say, 10 per cent of the weight. If such an engine were conservatively rated at 85 lb. per sq. in., that is, an equivalent output of 170 lb. per sq. in. on a four-stroke basis, the resultant weight per horsepower would be of the order of that of the gasoline type and the Diesel is at once placed upon a new footing altogether.

Table 1 is of particular interest in this connection. The author does not indicate where he obtained the data for this table. (Edward T. Vincent, Fuel Systems Engineer, Emsco Aero Engine Co., *Western Flying*, vol. 6, no. 2, August, 1929, pp. 46–47 and 160, *cp*)

TABLE 1 PERFORMANCE OF VARIOUS TYPES OF HIGH-SPEED OIL ENGINES

Engine	No. of cylinders	Bore and stroke, in.	Speed, r.p.m.	B.hp.	B.m.e.p., lb. per sq. in.	Max. pres., lb. per sq. in.	Fuel cons., lb. per b.hp-hr.	Weight, lb. per b.hp.
Beardmore	6	8.25 × 12	1400	700	103.0	850	0.43	3.36
Beardmore	6	8.25 × 12	1007	424	92.0	900	0.365	4
Beardmore	12	12 × 12	900	1500	81.0	800	0.42	22.8
Packard	9	5 × 5.5	1800	200	90.7	1200	0.44	3
Maybach	6	5.5 × 7.125	1300	150	90.0	..	0.49	17.65
M. A. N.	6	4.53 × 7.09	1000	68	78.4	..	0.437	22
Dornier	4	3.73 × 6.30	1000	35	100	..	0.46	...
Junkers	2	3.15 × 11.82	1200	54	96.5	..	0.38	16
McLaren-Benz	6	5.32 × 7.87	800	90	84.7	..	0.42	42.3

FUELS AND FIRING (See POWER-PLANT ENGINEERING: Will It Pay to Process Coal for Generating Power?)

INSTRUMENTS

The Bailey Thermo-Hydraulic Feedwater Regulator

THE article illustrates in particular the regulator valve used in this apparatus. One of its features is the recessed rings in the valve cage immediately below the valve seat. The purpose of these rings is to prevent cutting of seats and valve disks by wire-drawing at the tips of the V parts. Provision has been made for regulating feedwater by hand.

New features which are incorporated in this thermo-hydraulic generator, which is located at the boiler water level, are a cold water storage leg, a condensate bypass, and a vacuum seal. The cold water storage leg, together with a large fin area on the generator tube, assures rapid condensation of steam in the annular space between the inner and outer generator tubes, which in turn results in positive closing of the regulating valve as the boiler water level tends to rise. Condensate which forms in the connecting piping between the generator and the boiler drum is returned to the boiler by means of the condensate bypass. This prevents erratic and false operation of the regulating valve which would be caused if the condensate were allowed to drain back to the boiler through the generator. The vacuum seal causes instantaneous closing of the regulating valve in case the boiler water level ever exceeds the upper limit of variation allowed by the generator.

The drawing in the original article shows how the hydraulic connection between the sylphon of the regulating valve and the annular space between the tubes of the generator is made. (*Instruments*, vol. 2, no. 7, July, 1929, pp. 255–256, 3 figs., *d*)

INTERNAL-COMBUSTION ENGINEERING (See also AERONAUTICS: Aircraft Diesel-Engine Possibilities)

The Deutz High-Speed Diesel Engine

THIS is an airless-injection motor, developing, in one of the units now built, 200 hp. at 600 r.p.m. and weighing 55 to 65 lb. per b.hp. It is primarily intended for marine propulsion but can be used for coupling to generators, etc. The engine has separate liners of cast iron. The pistons are not cooled and are hollowed at the top.

The valves are actuated by long push rods lifted by cams on the camshaft enclosed within the crankcase on which are fitted the cylinders. All of the valves and the valve-operating mechanism are totally enclosed by cover plates. The flywheel is contained within a cast-iron casing, having a slot to enable the crankshaft to be turned. The space which is formed between the cover plates fitted over the engines and the cylinders acts as a suction chamber for the air, which is admitted through slots at the back of the casing. The noise of the suction is thereby diminished. Four- and six-cylinder engines have cylinders cast integrally, and they are bolted to the box-type crankcase. A common cast-iron water-cooled silencer is provided. The fuel pumps are in groups of two or four, and the injection pressure is around 5000 to 7000 lb. per sq. in.

The marine engine is directly reversible, and there are separate cams for ahead and astern operation, the camshaft being moved fore and aft by a hand lever before reversing. A lubricating-oil pump is fitted, drawing from the sump and delivering the oil through a filter and water-cooled cooler to the respective points requiring lubrication. A cooling-water pump of the gear-wheel type is driven from the crankshaft at half engine speed. A small air compressor is provided for starting purposes.

The fuel consumption at full power, as shown on the test curve, is 185 grams per b.hp-hr. or nearly 0.41 lb. per b.hp-hr., rising to about 0.42 lb. per b.hp-hr. at three-quarter load and 0.46 lb. at half load. (*The British Motorship*, vol. 10, no. 113, August, 1929, p. 200, 3 figs., *d*)

Detonation

THE following are among the factors on which the occurrence of detonation depends, according to the recent tests made by Harry R. Ricardo:

The rate of burning depends primarily upon the degree of turbulence and may be expressed in terms of increase of pressure per degree of crank angle. In order the more accurately to determine the rate of pressure rise during combustion, a Farnboro' electric indicator was provided and operated in such a manner as to magnify the relationship between crank angle and gas pressure. The diagrams were taken only over a range of crank angle of about 75 deg. on either side of top dead center, and the actual records gave a pressure scale of 84 lb. per sq. in. and a crank-angle scale of 12 deg. per inch.

To a secondary extent the rate of burning depends upon the compression ratio; the higher the compression the more rapid the burning and therefore the less the need for turbulence.

At any compression ratio the best power output and efficiency are obtained on full load when the rate of pressure rise is approximately 30 lb. per sq. in. per degree of crank angle, but at light loads a somewhat greater degree of turbulence is desirable. In this connection the author calls attention to delayed combustion.

In the so-called "turbulent" head, turbulence is set up to an almost equal degree by (*a*) the initial velocity through the inlet valve; (*b*) the velocity through the restricted throat during compression. It is intensified also by the final ejection just prior to ignition of the gases entrapped between the piston and cylinder head. During the series of experiments referred to, each of the above factors was varied individually step by step and its influence evaluated.

In all cases the best possible position for the spark plug is nearly in the center of the "effective" combustion chamber, not quite in the center, but with a slight bias toward the exhaust valve head, since this neighborhood is necessarily the hottest zone and should therefore have the shortest flame travel. Only a slight bias is desirable, however. If pushed too far over toward the exhaust valve, the length of flame travel in the other direction then becomes too great.

Data on the effect of the position of the spark plug are given in the original article from experiments on a turbulent head. Among other things the author points out that the effect of turbulence alone upon the tendency to detonate and as distinct from much more important factors such as length of flame travel is appreciable but not outstanding. A series of tests was carried out in order to determine the influence of shape of head generally. (First of a series of articles under the title of "Cylinder Head Design," by Harry R. Ricardo, F.R.S., in *The Automobile Engineer*, vol. 19, no. 256, July, 1929, pp. 257–261, 12 figs., *de*)

MACHINE PARTS

Coil Springs

THE author discusses the subject of coil springs generally and classifies them into four classes: compression, extension, torsion, and flat. For mechanical engineers the most interesting part is that dealing with spring specifications, which is as follows:

Compression springs have five principal dimensions: outside diameter, inside diameter, length, size of wire, and pitch or number of coils. In many cases it is not possible to specify them all, and often it is not advisable to try; but we do need sufficient information to enable us to determine them all.

As to diameters, either outside or inside, and sometimes both, are determined by fixed dimensions of other parts. When this is the case it is advisable to specify the maximum outside and minimum inside diameters permissible. If one is fixed and the other immaterial within reasonable limits, so state. If clearances are required within a tube or over a rod, specify inside diameter of tube and diameter of rod. With springs of large diameter, and particularly if the pitch is greater than three times the wire size, it should be borne in mind that the diameter will increase as the spring is compressed, and proper clearance allowed for this.

Length when free is often of no great importance if lengths under load conditions are met; but if compression springs are required to carry a definite load in pounds at one compressed length, it is necessary to know either the free length required or have some fairly definite idea of the rate, or load per inch, in order to design a spring properly. For instance, a specification requiring a load of 100 lb. at 5 in. long, with no qualifying specifications, could be met in various ways by using relatively light wire and a great free length, by using heavy wire and a free length only slightly over the 5 in., and many gradations between. But if the requirements covered a spring 7 in. in free length, to carry 100 lb. at 5 in. long, this is definite and fixes the rate, or scale per inch, at 50 lb.

Conversely, were the specification for a load of 100 lb. at 5 in. and a rate of 50 lb. per in., the free length is fixed at 7 in. Obviously, therefore, a specification covering a load at a given height, a free length, and a rate per inch, must "check" as to these proportions, since in an ordinary helical compression the load is in direct proportion to the deflection. Another specification which often occurs is where two loads are required, at different lengths; for instance, 100 lb. at 5 in. long and 75 lb. at 6 in. long.

In such a case one definite free length, and one only, will satisfy the conditions. The difference in loading is 25 lb. for a difference in length of 1 in., therefore the rate per inch is 25 lb. It would be necessary to compress the spring from its free length, then, a distance of 3 in. to build up the initial load of 75 lb., therefore the free length must be 9 in. A spring of any other length would fail to meet either one load or the other, whatever its rate per inch.

Oftentimes the length a spring may occupy when closed, or fully compressed, is limited by dimensions of other parts. This should be stated in such cases. It often happens that proper spring space is not available in designs already fixed to enable the springmaker to design the best spring for the use required. In such cases the only possibility is the best compromise design which can be worked out, and often at the expense of the length of life of the spring. Wherever a spring is an important member of any mechanism, it should be carefully considered in the original design of all other parts, an efficient spring obtained first, and the dimensions of other parts arranged to provide the spring space necessary. (E. W. Stewart, Sales Mgr., The Wm. D. Gibson Co., Chicago, in *Wire and Wire Products*, vol. 4, no. 8, Aug., 1929, pp. 262–264, 1 fig., *dp*)

MARINE ENGINEERING

"Answer" to "Ersatz Preussen"

THE German cruiser *Ersatz Preussen* was briefly referred to in an editorial in MECHANICAL ENGINEERING, vol. 51, no. 5, May, 1929, p. 393. By skilful engineering the Germans have achieved what was considered to be impossible, viz., turning out a vessel with a displacement of 10,000 tons but armed with six 11-in. guns and in speed superior to any dreadnaught. The result is that with the exception of the seven existing battle cruisers, the *Ersatz Preussen* can outrun any ship carrying a heavier battery and outfight any ship having greater speed.

In projecting a type of vessel with which to "answer" the *Ersatz Preussen*, three qualities are obviously essential: First, the speed of the German vessel must be exceeded; second, protection must be at least equal; and third, the battery must be superior. Such a vessel embodying these desiderata would be a

cruiser of from 15,000 to 18,000 tons displacement, depending upon the speed selected. This increase of tonnage over 10,000 is desirable in order to provide for a considerable, rather than a slight, superiority in battery and protection over the *Ersatz Preussen*, as well as to leave a safe margin, should the German designers succeed in effecting a marked improvement in a later ship.

The speed should not be less than 31 knots. Protection should be effected through extreme subdivision, with the armor at least 5 in. on the belt, 4 in. on the barbettes, and 3 in. on the armor decks. The battery should include not less than six 14-in. guns, although 12-in. guns might possibly be substituted provided a sufficiently high muzzle velocity could be obtained.

This ship would be in effect a small battle cruiser; but its construction would be in contravention of the treaty of Washington both as to tonnage and as to caliber of guns.

The authors compare the *Ersatz Preussen* and the *Pensacola*. As to proportions and dimensions, it will be noted that the German design provides the greater length, thereby obtaining a desirable speed-length ratio, even at its lower speed, and conserving the power requirements. The ratio of length to beam is almost identical in the two cases, being slightly less for the *Pensacola*. The designed draft of the *Ersatz Preussen* is not definitely known, but is reasonably assumed to be close to 19 ft.

The combination of these dimensions shows the *Ersatz Preussen* to have a somewhat fuller model, as would be expected for the slower speed. It introduces the possibility, however, of a relatively lower prismatic coefficient and consequently a further conservation of power. A rough approximation of horsepower of the two vessels at 26 knots shows that that of the *Ersatz Preussen* would be slightly greater if equal midship section coefficients are assumed, and slightly lower if the prismatic coefficients are equal.

Machinery of the *Pensacola's* geared-turbine type should run about 50 shaft horsepower per ton for all purposes. The M.A.N. geared Diesel drive would ordinarily be expected to weigh slightly more per shaft horsepower, but it is understood that important reductions in machinery weight have also been accomplished by advanced design for the *Ersatz Preussen*. The difference in machinery weight between this vessel and one of the *Pensacola* type is therefore enormous, and is available for armor and armament.

The outstanding advantage of the Diesel drive in the *Ersatz Preussen* is the unheard-of cruising radius which it permits. The problem of backing power, always present with turbine drive, is also eliminated. In considering the Germans' choice of machinery, however, it must be kept in mind that cruising radius is of greater importance to the German Navy than to any other of the principal navies.

The question of armament, particularly as affecting the stability of the ship, is discussed in detail. (R. W. Morell, Naval Architect, New York City, and F. W. Morrell, formerly Lieutenant, U.S.N., in *Marine Engineering and Shipping Age*, vol. 34, no. 6, July, 1929, pp. 355–357 and 377, *c*)

METALLURGY

The High-Temperature-Resistant Metal "Konel"

THIS metal has been developed by the Westinghouse Electric and Manufacturing Co. (Dr. E. F. Lowry) and is intended to be used in place of platinum in the manufacture of radio tubes. It may be used for moving parts in internal-combustion engines, because of its ability to retain its strength at high temperatures. It is even said that the metal gains tensile strength as the temperature increases. "Konel" is a combination of cobalt, nickel, and ferrotitanium. (*Westinghouse Technical Press Service*, A-06381, and statement published in *The New York Times*, Sept. 10, 1929, p. 31, *g*)

POWER-PLANT ENGINEERING (See also INSTRUMENTS: Bailey Thermo-Hydraulic Feedwater Regulator)

Modern Feedwater Circuits

THE fundamental cycle traversed by the working fluid in all steam-power installations is from boiler to power generator, from power generator to condenser, and from condenser back to boiler. Superimposed on this simple circuit there are generally several subsidiary heat exchangers, and furthermore complexity is introduced by the presence of leakage and consequent necessary

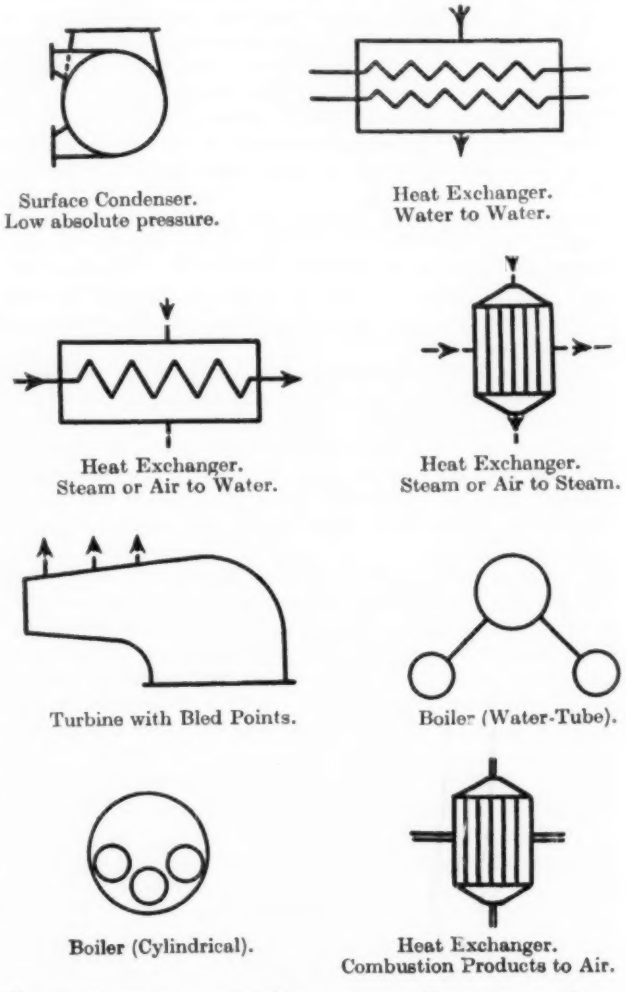

FIG. 5 CONVENTIONALIZED NOTATION FOR ELEMENTS OF FEEDWATER CIRCUITS

provision for makeup. Where very high steam pressures are used there is an increase in the tendency to introduce in various forms what may properly be termed a subcircuit. The subcircuit may even be of a material other than steam, such as mercury. The author considers a number of such circuits, some of them merely for the sake of illustrating the principles, and others of practical value. This part of the paper, as well as the discussion in which several additional feed circuits have been brought out,

is not suitable for abstracting. In his diagrams the author uses a conventionalized notation reproduced in Fig. 5.

The paper with the discussion forms an interesting addition covering broadly the subject of feedwater circuits. (J. G. Weir, *The Proceedings of the Institution of Mechanical Engineers*, no. 1, January, 1929, original paper, pp. 5–21, 22 figs., and discussion, pp. 22–40, *dA*)

Will It Pay to Process Coal for Generating Power?

TO ANSWER this question the authors consider the case of several plants, each assumed to serve a district capable of consuming the output of a 150,000-kw. plant operating with an average load factor of 60 per cent. The value of the article lies in the figures given to show the disposal of the products of a process coal plant.

While there is no definite relation for relative loads for electricity and gas holding good for the whole country, it appears that in the average American community approximately 10 cu. ft. of gas is distributed for every kilowatt-hour of electricity consumed.

The principal markets for coke are for foundry and blast-furnace use, water-gas manufacture, and the domestic trade. All except the latter are either too small or too subject to fluctuations to depend upon. As to domestic consumption, the authors claim to have data which rate the solid domestic fuel consumption at about 4 lb. per kw-hr. consumed. This would indicate that local demand would not be sufficient to take care of the coke produced from processed fuel if the latter has been sufficient to generate all the electric energy required.

Such by-products as ammonium sulphate, coke-oven tar, and creosote oil can apparently be disposed of without much trouble at standard market prices, but there will be greater difficulty in the disposal of low-temperature and water-gas tar. A table in the original article gives estimated yields of all the products per ton of coal processed as well as the quantities used in operation.

The plant scheme selected for study has an installed capacity of 150,000 kw., consisting of three multi-stage condensing turbine generating units. The steam equipment consists of six 21,000-sq. ft. boilers which furnish steam at 600 lb. and 725 deg. fahr. The feedwater makeup from single-effect evaporators, with the turbine condensate, is preheated to 360 deg. fahr. in two open-type and one closed-type heaters with steam bled from the turbines. The temperature of the stack gases leaving the economizers is 300 deg. fahr.

When the power-generating plant is gas-fired the power units remain the same as in the coal-fired installation except as to coal-handling equipment. For gas firing, simple bunsen-type burners are installed.

For the coke-oven installation the modern regenerating type of oven has been used. The ovens have a capacity of 14.31 tons of coal per charge, and when operated at full capacity have a throughput of 28.62 tons per day.

The by-product equipment is of sufficient size for handling all the products when the ovens are operated at maximum speed. In all cases tar, light oil, and ammonium sulphate are recovered. Sufficient storage capacity is provided for these products to insure economical marketing.

Three cases have been considered where the sale of gas enters into the cost of power; in the first case, only the surplus oven gas is available for sale; in the second case the entire production of oven gas is so available; while the third case is partly similar to the first, but the oven gas is mixed with blue gas. The author considers in detail the importance of each of the products of processing as affecting the total economic results of the plant operation, and comes to the following conclusions which do not appear to put the proposition in a favorable light.

1 With a combined coke-oven power-generating plant it is possible to generate power with coke and breeze more cheaply than in a straight steam-generating plant. However, the returns on the additional capital investment in the coke-oven plant are only 5 per cent to 10 per cent, an amount insufficient to justify the construction of such a combined plant.

2 With a combined complete-gasification-retort power-generating plant it is possible to generate power more cheaply than in a straight steam-generating plant, but not as cheaply as in a combination coke-oven power-generating plant using pulverized coke and breeze as fuel.

3 That any combined gas-electric plant dependent upon the sale of coke as a by-product is unprofitable due to the large increase in capital investment required and also due to the difficulty of disposing of large quantities of coke at a price sufficiently high to cover conversion costs.

4 That there is not sufficient justification for building a combined gas-electric plant that is dependent upon the sale of gas as a by-product, owing to the large increase in capital investment required.

5 That a combined gas-electric plant is profitable only if its cost is equal to, or but slightly exceeds, the cost of a straight steam-generating plant.

6 The capital requirement for any combined gas-electric plant, where provision is made for the recovery of all by-products from coal processing and their preparation for marketing, is so much greater than for a straight steam-generating plant that the possibility of cheapening electric power generation by processing bituminous coal appears remote. (Walter R. Knapp, Cons. Engr., New York City, and Paul McMichael, W. L. Phillips Co., New York City, in *Chemical and Metallurgical Engineering*, vol. 36, no. 5, May, 1929, pp. 281–285, *spA*. The article is based on an engineering report prepared for Stevens & Wood, Inc., New York City.)

In connection with the above abstract it will be of interest to recall the fact stated in the daily papers that the Industrial Power Corporation, working through Stevens & Wood, the engineering subsidiary of the Allied Power and Light Corporation, proposes to convert the properties of the Produce Exchange Corporation in the stockyards district of Chicago into a central-station plant in which all of the fuel used will be treated by low-temperature carbonization to extract the by-products. The carbonization plant is said to have been designed for an ultimate capacity of 45,000,000 cu. ft. of gas daily, all of which is to be sold.

Contemporary Practice in Condenser-Surface Dimensions

THE author compares the cooling surface in square feet per unit of power for the various types of steam prime movers and indicates what causes the differences. In order to render available in some measure the guidance afforded on this question by temporary design and performance, Figs. 6 and 7 have been prepared.

Fig. 6 gives values of the designed overall heat-transmission coefficient K, in B.t.u. per sq. ft. per hr. per deg. fahr. of mean temperature difference, plotted against the primary variable of cooling-water velocity through the tubes in feet per second, for a considerable number of published cases from actual practice. Fig. 7 shows overall heat-transmission coefficients, calculated from published test results, which have been actually obtained from condensers in service. With the exception of the one giving the points marked x, which was subject to excessive air leakage, these condensers did not depart abnormally from accepted standards as to airtightness, and all except those giving the points marked y were either new or reported in clean condition.

In Fig. 6 the values shown are for designed full power. In Fig. 7 they are for overload, full-power, or closely approaching full-power operation, and thus avoid the low overall K values which

may appear at low loads due to the extension of the secondary portion of the tube bank at the expense of the primary, a point which has been dealt with at length by the writer elsewhere. In both figures the K values for marine reciprocating machinery have been based on a uniform assumed steam consumption for triple-expansion engines of 14 lb. per i.hp-hr. and a value for the heat rejected to the condenser of 1050 B.t.u. per lb. In Fig. 6 the heat-transmission coefficients for marine geared turbines

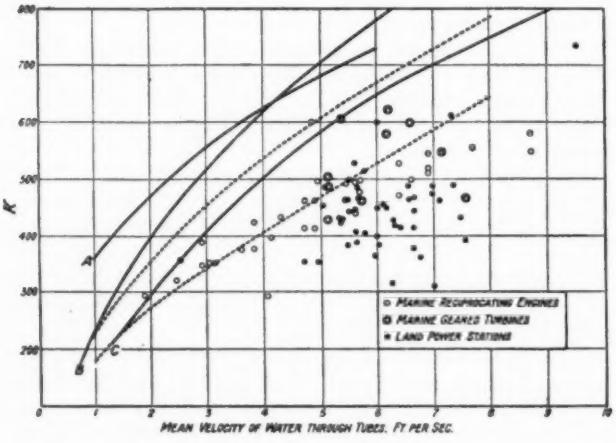

FIG. 6 PRACTICE IN CONDENSER SURFACE DIMENSIONS IN PUBLISHED DESIGNS

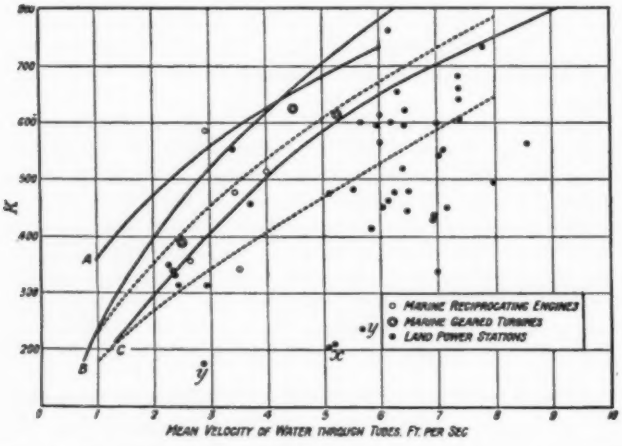

FIG. 7 PRACTICE IN CONDENSER SURFACE DIMENSIONS, ACTUAL RESULTS

and for land power-station plants are based upon the estimated full-power consumption, and where possible and convenient, on the net heat rejected to the cooling water per pound of the steam. In other cases the heat rejected has been assumed at 1000 B.t.u. per lb. The same procedure has been followed in Fig. 7 in the case of marine and land turbines, except that actual measured steam consumptions have been used in every case and the net rejected heat in the majority. In both of the figures most of the values given for land power-station plants refer to units of the largest size.

Three curves shown by solid lines have been drawn on each figure. Curve A is the mean curve of experimental results of various engineers and is given as Fig. 9 in the 9th Report of the Ministry of Munitions and Department of Scientific and Industrial Research, Technical Records of Explosive Supply, 1915–1918. Curve B represents the 1910 experiments of Geo. A. Orrok, and curve C gives the results of a test by the Westinghouse Electric and Manufacturing Co. on a new 1-in. tube under actual operating conditions, using river water containing considerable debris.

The further curves, shown in dotted lines, which have also been drawn on each figure, are based upon the values given by Mr. H. M. Martin in Table 5 of his article on "The Laws of Heat Transfer." These curves with their terminal ordinates, delineate the field of proposed heat-transmission coefficients for practically air-free steam, clean tubes, $^3/_4$-in. external diameter, and a steam load of 8 lb. per sq. ft. of cooling surface per hr., the lower curve being for cooling water in which the mean of the inlet and outlet temperatures is 45 deg. fahr., and the upper for a mean temperature of 75 deg. fahr. For cooling water at intermediate mean temperatures, the heat-transmission coefficients must be interpolated in the field. The curves are based upon arithmetical mean temperature differences, and are thus lower than would be obtained on a hyperbolic mean-temperature-difference basis, a fact which should be remembered in comparing them with curves A, B, and C.

Both groups of curves cover a wide range of operation. The results of actual operation tend to generally higher reaching in cases even beyond the curve C and thus justify the design values of Fig. 6 as conservative predictions of performance under actual operating conditions. The variation in results was probably due in the main to differences in air leakage, as the condensers concerned were new or reported as being in clean condition.

In selecting by the aid of Figs. 6 and 7, or charts similarly constructed an overall heat-transmission coefficient for purposes of design, regard should be had to the quality of the circulating water available, the length of time which must elapse between the periodical cleaning of the tubes, and the standard of maintenance and operating deficiency to be anticipated. Thus the higher standard of maintenance and operating efficiency in naval vessels and those of the liner class warrants the assumption of a somewhat higher K than for cargo vessels. On the other hand, the high standard of maintenance and operating efficiency in large central electric power stations will not enable an ample margin to be dispensed with where the circulating water is of a deposit-producing character, and if, in anticipation of a lower standard of operating efficiency, it is desired to provide a margin against both excessive air leakage and surface deterioration, the design of an overall heat-transmission coefficient must be assumed at a low figure. Allowance should also be made for the size of tubes it is proposed to use, the vacuum required, the steam load, and the temperature of the circulating water; large diameter of tubes, high vacua, and low steam load and temperature of circulating water being unfavorable to high transmission coefficients. (Thos. Petty in *The Power Engineer*, vol. 24, no. 281, August, 1929, pp. 306–307 and 337, 2 figs., *dp*)

RAILROAD ENGINEERING

Diesel Locomotive With Robertson Variable Gear

REFERRING more particularly to the automatic gear, it will be observed from Fig. 8 that the drive is taken from the engine flywheel through a flexible coupling C attached to the flywheel D, thence through a sleeve E to shaft F, which carries a cam disk G and a metal friction cone disk K. A sleeve J, splined internally and free to slide on the cam disk shaft, but rotating with it, carries the spring-loaded governor weights KK, the whole rotating in an oil-tight case L, a collar M being located on this sleeve by a ball bearing, the position of which is controlled by a hand lever N.

The cone disk H engages a floating annular friction ring O, which in turn engages a fixed friction ring P, both of which are mounted on the outer radius spindle of a planet gear train SSS.

The planet gear is free to rotate about the axis of shaft R through some 32 deg.

Pressure for driving contact between the friction disk and the floating ring is obtained from the centrifugal force generated by the governor weights, resisted by the reaction through the gear train.

When the engine is idling and the locomotive stopped, the centrifugal force generated in the governor weights is insufficient to overcome the spring loading, therefore there is nothing to prevent the cam disk G being drawn back toward the engine flywheel, so that H is entirely out of contact with the friction ring O. On starting, the driver places lever N in any one of the graduated notches, which has the effect of moving collar M away from the engine flywheel and bringing friction cone disk H in close proximity to floating friction ring O; but as long as the engine is idling the governor weights KK are not extended out, and therefore the friction cone H does not make actual contact with friction ring O.

As soon as the driver opens the engine throttle, however, the engine speeds up, the governor weights being out, and the cone disk H presses heavily upon friction ring O. The tendency, therefore, is to drive O, but the inertia of the train and locomotive tend to hold shaft R stationary and in consequence the planet gear rotates about shaft R, carrying with it the casing Q and the two friction rings. Contact between disk H and ring O then takes place eccentrically, which has the effect of lowering the gear. When a sufficiently low ratio has been reached, the inertia of the train is overcome and the locomotive moves forward.

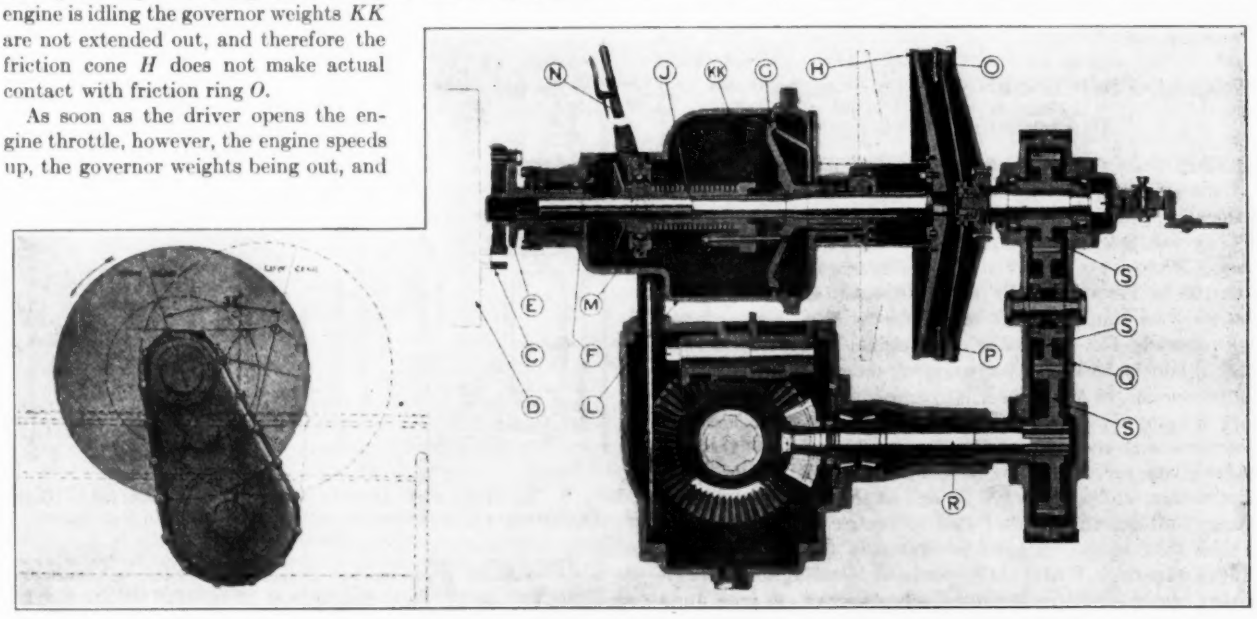

FIG. 8 END VIEW OF FRICTION DISK AND CROSS-SECTION OF THE ROBERTSON VARIABLE GEAR

As soon as the trains get under way the torque reaction which caused the gearcase Q to revolve around shaft R decreases, the governor weights swing further out, and the friction ring commences to climb back toward the greatest diameter of the friction disk H, thus raising the gear. As more and more way is got on the train this process continues until, as soon as the train is properly started, friction ring O comes back to a concentric position with friction disk H, and the whole gear drives as a single-plate clutch.

If an incline has to be negotiated which is beyond the power of the engine to handle on top gear, the increased torque reaction through the gear train will tend to make casing Q once more revolve about the countershaft. The lowering of the engine speed, due to the increased demand, will cause the centrifugal force of the governor weights to diminish, and the gear will be lowered until the increase in the engine speed and the lowering of the gear ratio reestablish a balance. (*The Machinery Market*, no. 1497, July 12, 1929, p. 25, *dA*)

Optical Train Control on the German State Railways

THE controlling influence in the optical system is light, which, with the assistance of optical apparatus between the locomotive and the signal, is sent to and from and assures the intended operation. It would be the simplest technical solution to equip every signal with a light source and transmitter, which would emit light at the stop position of the signal, and to provide every locomotive with a receiver which would be illuminated on the passing of the locomotive. But since in Germany at the present time it is not possible to furnish an individual light source at every signal, because the electric lighting of signals is still restricted to exceptional cases, the arrangement has been reversed, that is, the source of light and the transmitter have been arranged on the locomotive, and a reflecting device, a mirror, placed on the signal, which receives the light from the transmitter and throws it back to the receiver upon the locomotive. The mirror changes its position according to the position of the signal and at the same time its effect upon the receiver.

The transmitter is a reflector operated by an incandescent light. A selenium cell behind a small lens serves as a receiver. On the passing of an operative mirror by a locomotive the reflected light falls upon the selenium cell. A special triple mirror is used so that slight changes of the rails or of the mirror, rolling of the locomotive, and high-speed operation should not affect the correct functioning of the cell. Protection against foreign light that might affect the action of the selenium cell is also provided, in addition to which the apparatus is protected against the influence of water.

The optical system of train control incorporates all of the established fundamentals of train control; the principle of acknowledgment and of speed control. With the principle of acknowledgment the first point of control is the advance signal. If this stands at "caution," which means that the home signal is at "stop," the train receives an indication that, at the expiration of five seconds, operates automatically upon the brake system to reduce the speed, provided the engineman has not taken proper

action before that time. If he has received the caution signal properly, and wishes to avoid setting the brakes, he must, within these five seconds, make use of an acknowledging lever, by which means he puts the automatic control out of operation and again secures the full control of the train. In order to control the further systematic speed reduction, between the advance and home signals, after the expiration of a certain time (say, 15 sec.), a speed-control device operates, which remains in force up to the home signal and compels the engineman, even in the case of intervening signals to maintain this reduced speed. But if he should again speed up the train, the brake-setting operation ensues. This speed control must extend over a stretch of from 80 to about 45 kilometers for passenger trains. A certain overrunning of stop signals cannot, in this way, always be avoided.

The advantages of optical control are enumerated in the original article. (*Railway Signaling*, vol. 22, no. 8, August, 1929, pp. 299–302, 8 figs., *d*)

SPECIAL PROCESSES

Hydrogenation of Petroleum

HYDROGENATION marks the first substantial move toward the application of the basic principles of chemical synthesis in the petroleum industry. Heretofore in cracking practice gasoline has been produced by a destructive rather than constructive reaction. Now by the introduction of hydrogen under pressures from 100 to 300 atmos. and in the presence of a catalyst, it is possible to build up the hydrocarbons desired and thus to convert approximately 100 per cent of the original oil into gasoline or other products. Carbon formation is actually eliminated and the production of fixed gases is reduced to a minimum. The work is being done by the Standard Oil Co. of New Jersey in agreement with the German Dye Trust. No details of the process are given, except that it is stated that the plants now under construction (at Bay Way, N. J., and at the Baton Rouge, La., refinery) utilize what are reputed to be the largest alloy-steel forgings that have ever been fabricated in the United States. (S. D. Kirkpatrick, Editor of *Chemical and Metallurgical Engineering*, in *Chemical and Metallurgical Engineering*, vol. 36, no. 6, June, 1929, pp. 332–333, illustrated, *g*)

THERMODYNAMICS

Heat Transmission in Condensation of Superheated and Saturated Steam

ALTHOUGH the condensation of steam is one of the most common processes in engineering, very little is known as to what really occurs when condensation takes place. It is still, therefore, a question as to whether it is proper to use superheated steam as it is for heating evaporators, preheaters, etc., or whether it is preferable to convert it into saturated steam by an injection of a spray of water. Such experiments as have been made do not appear to have solved this question with sufficient reliability; in fact, no definite method of measurement has been established to determine the qualities of superheated and saturated steam as carriers of heat. An apparently well-founded theory of surface condensation has been put forward by W. Nusselt. Stender was the first to draw from it the conclusion that condensed superheated steam is preferable to saturated steam as a carrier of heat.

Since the Nusselt theory has not been experimentally tested for the case of flowing steam, the present authors have undertaken to determine (at first for the simplest case, viz., a vertical pipe through which steam at one atmosphere pressure was flowing) if the condensation of saturated steam is preferable to that of superheated steam from the point of view of heat transfer. Some of the data thus obtained are given in the present article, which is an advance publication of a more elaborate monograph.

These tests will be continued in order to throw more light on the process of condensation and thus facilitate the calculations involved in the design of condensers and heat exchangers. Very extensive work will be necessary to do this because condensation is effected not only by convection of heat and by flow phenomena of gases and liquids, but also by the changes in the state of the fluids involved. The means for carrying on this work were provided by the Community of Interests of German Science and the Verein Deutscher Ingenieure.

The process of testing was designed on the basis of determining calorimetrically the amounts of heat given up by the steam to the

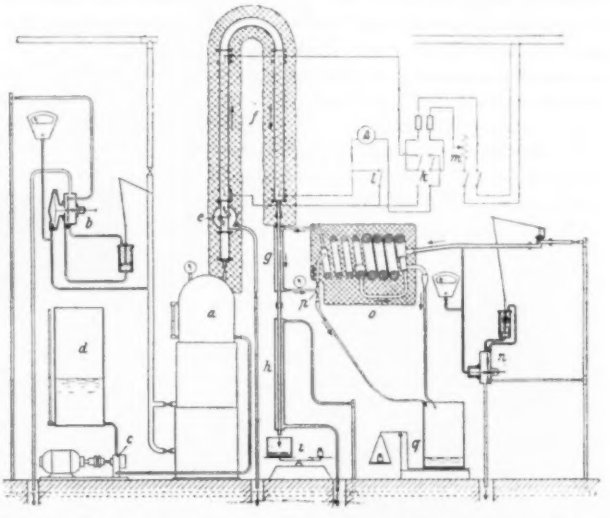

FIG. 9 EXPERIMENTAL INSTALLATION FOR DETERMINING HEAT TRANSFER IN CONDENSATION OF SUPERHEATED AND SATURATED STEAM

(*a*, steam boiler; *b*, gas regulator; *c*, feedwater pump; *d*, feedwater tank; *e*, water separator; *f*, superheater; *g*, experimental tube; *h*, condenser; *i*, scale; *k* and *l*, switches; *m*, rheostat; *n*, water-flow regulator; *o*, heat exchanger; *p*, two-way valve; *q*, scale.)

tube through which it was flowing, this being done by measuring the quantity of cooling water and its rise in temperature, at the same time taking measurements not only of the amount of steam and its entrance and exit temperatures, but also the temperature of the tube wall. In so far as the authors are aware, the wall temperature was not measured in previous tests, and the authors consider this to be the principal reason that these tests have not been as satisfactory as they might have been.

A vertical tube with the steam on the inside and the cooling water flowing on the outside was selected because the cylinder is the simplest and technically the most important heat-transfer surface, and also because, on account of symmetry, the simplest possible functional relation exists. As it was desirable to establish not only the influence of the wall temperature but also that of the velocity of the flow of steam, only a part of the steam was condensed in the "experimental tube" itself, it being under this condition only that the average velocity could be calculated with sufficient precision from the entrance and exit velocities. The remainder of the steam was condensed in a second tube in order to determine by weighing the condensate the total amount of steam going through the experimental tube.

The experimental arrangement is shown in Fig. 9. The steam in amounts up to 40 kg. (88 lb.) per hr. was taken from a small boiler in which the supply of heat was maintained constant by means of the radiant regulator *b* with diaphragm control. From the boiler *a* the steam passed through a water separator *e*, an

electric superheater *f*, the experimental tube *g*, and finally reached the condenser *h*. The condensate was weighed on the scale *l*.

In order to carry out tests with various wall temperatures, the cooling water was preheated before it was permitted to enter the jacket of the experimental tube. A counterflow cooler *o* taken from a Linde air-liquefaction outfit was used for this purpose.

By properly setting valve *p*, more or less preheated water was admitted and this regulated the temperature of the cooling water, the quantity of which was determined by weighing it on scale *q*.

The experimental tube was of drawn brass 17 mm. (0.669 in.) in diameter and was surrounded by another tube 40 mm. (1.57

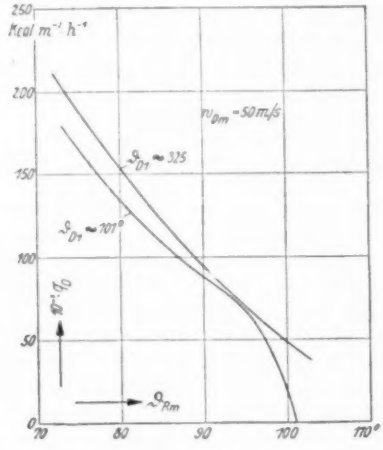

FIG. 10 HEAT GIVEN UP BY SUPERHEATED AND SATURATED STEAM AS A FUNCTION OF WALL TEMPERATURE OF THE CONDENSATION VESSEL

(For an average steam velocity of 50 m. [164 ft.] per sec. Ordinates, large calories per square meter per hour; abscissas, degrees centigrade.)

in.) in diameter. The temperature of the steam was measured by thermal elements set in tiny brass tubes and located directly in front and behind the portion on which the measurements were made. The temperature of the cooling water was determined at the inlet and outlet by thermometers, while the temperature of the tube wall 1 mm. (0.039 in.) thick was determined by thermal elements located in a brass tube soldered to the experimental tube. This brass tube was 1.5 mm. (0.059 in.) inside diameter and 0.75 mm. (0.029 in.) thick.

The tests have shown that the heat given up by the steam to the water-cooled wall depends on the difference between the steam temperature and wall temperature and also on the velocity of flow of steam. For an average velocity of flow of steam of 50 m. (164 ft.) per sec., q_D, the amount of heat transmitted per hour per square meter of area (10.76 sq. ft.) is given in Fig. 10 as a function of the average wall temperature θ_{Rm} for superheated steam of about 325 deg. cent. (617 deg. fahr.) and for saturated steam of about 101 deg. cent. (213.8 deg. fahr.). For the same wall temperature, the amount of heat given up by superheated steam is somewhat greater than that given up by saturated steam. The two lines, however, are drawn for equal steam velocities and hence equal steam volumes, but for different masses of steam. Should, however, equal masses of steam flowing per unit of time be made the basis of calculation, then the important influence of the velocity of steam would not show up. A basis of comparison theoretically satisfactory and convenient practically is obtained by using the amount of heat given up to the cooling surface by the flowing steam. The maximum possible amount of heat Q_E (in large calories per hour) would appear to be transferred to the wall when all the steam is condensed and the water of condensation is cooled on the wall to the temperature θ_{Rm}. Actually, however, a smaller amount of heat Q_W (in large calories per hour) is transmitted and the ratio $\beta = Q_W/Q_E$ is called the quality factor of heat transfer.

In Fig. 11 this quality factor β is plotted as a function of the heat Q_E transmitted with various temperatures of wall and steam. It is obvious that for $Q_E = 0$ this quality factor is equal to unity. As Q_E increases, the factor β for the same wall temperature becomes smaller because the film of water interfering with the heat transfer becomes thicker. On the other hand, as the wall temperature decreases the factor β increases for the same amount of heat supplied Q_E, because in such a case more of the flowing steam is condensed on a colder wall. The influence of the steam temperature is less clear. As Q_E increases, the factor β becomes higher for superheated steam than for saturated steam. The conditions are more favorable in the case of saturated steam when Q_E is small. Just what influences are affecting the situation in this case, the authors do not clearly see. A comparison of the results of the investigation here described with the theory of Nusselt would indicate that fundamentally this theory is confirmed, but for purposes of exact calculations, particularly in the region of low wall temperatures, the Nusselt theory should not be used. In some of the experiments the average wall temperature was above the saturation temperature of the steam. It was found that as the wall temperature increases the heat transfer on the cooling-water side does not vary in jumps even at the beginning of the boiling; on the other hand, however, the separation of gas bubbles and formation of a layer on the wall on the cooling-water side might have strongly af-

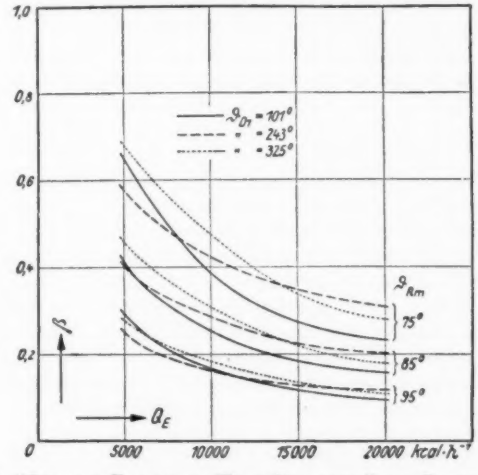

FIG. 11 "QUALITY FACTOR OF HEAT TRANSFER" FOR SUPERHEATED AND SATURATED STEAM DEPENDING ON THE AMOUNT OF HEAT SUPPLIED WITH VARYING STEAM AND WALL TEMPERATURES

fected the heat transfer and might be the cause of instances of experimentally poor heat transfer with superheated steam observed occasionally in practice.

The main conclusion from this investigation is that the heat given up during condensation of superheated and saturated steam decreases with increasing wall temperature and increases with increasing velocity of flow of steam. By introducing the conception of quality factor of heat transfer, the authors believe that it is possible to show in a satisfactory manner that the heat transfer in the case of condensing superheated steam is, on the whole, somewhat better than in the case of saturated steam. (M. Jakob and S. Erk, Berlin. Communication from the National Physico-Technical Institute, to appear in complete form in Forschungsarbeiten, No. 310. Published in abstract in *Zeitschrift des Vereines deutscher Ingenieure*, vol. 73, no. 22, June 1, 1929, pp. 761–762, 3 figs., *eA*)

Revisions and Addenda to the Boiler Construction Code

IT IS THE policy of the Boiler Code Committee of The American Society of Mechanical Engineers to receive and consider as promptly as possible any desired revision of the Rules and its Codes. Any suggestions for revisions or modifications that are approved by the Committee will be recommended for addenda to the Code, to be included later on in the proper place in the Code.

The Boiler Code Committee has received and acted upon a number of suggested revisions which have been approved for publication as addenda to the Code. These are published below, with the corresponding paragraph numbers to identify their locations in the various sections of the Code, and are submitted for criticism and comment thereon from any one interested therein. Discussions should be mailed to the Secretary of the Boiler Code Committee, 29 West 39th St., New York, N. Y., in order that they may be presented to the Committee for consideration.

After 30 days have elapsed following this publication, which will afford full opportunity for such criticism and comment upon the revisions as approved by the Committee, it is the intention of the Committee to present the modified rules as finally agreed upon to the Council of the Society for approval as an addition to the Boiler Construction Code. Upon approval by the Council, the revisions will be published in the form of addenda data sheets, distinctly colored pink, and offered for general distribution to those interested, and included in the mailings to subscribers to the Boiler Code interpretation data sheets.

For the convenience of the reader in studying the revisions, all added matter appears in small capitals and all deleted matter in smaller type.

PAR. P-183. REVISED:

P-183. On longitudinal joints OF ALL TYPES OF BOILERS AND ON CIRCUMFERENTIAL JOINTS OF DRUMS HAVING HEADS WHICH ARE NOT SUPPORTED BY TUBES OR THROUGH STAYS, the distance from the centers of rivet holes to the edges of the plates, except rivet holes in the ends of butt straps, shall be not less than $1^1/_2$ and not more than $1^3/_4$ times the diameter of the rivet holes; this distance to be measured from the center of the rivet holes to the calking edge of the plate before calking. The plate edge shall be beveled to an angle not sharper than 70 deg. to the plane of the plate and as near thereto as practicable.

PAR. P-184*d*. REVISED:

P-184*d*. The distance from the centers of rivet holes of circumferential joints to the edges of the plate IN BOILERS HAVING HEADS WHICH APE SUPPORTED BY TUBES OR THROUGH STAYS shall not be less than $1^1/_4$ times the diameter of the rivet holes.

PAR. P-186. ADD THE FOLLOWING:

ELECTRIC RESISTANCE BUTT WELDING, WHERE THE ENTIRE AREA IS WELDED SIMULTANEOUSLY, MAY BE USED AND THE ULTIMATE STRENGTH OF THE JOINT TAKEN AS 35,000 LB. PER SQ. IN. AS IN THE CASE OF FORGE WELDING. IT MAY, UPON THE REQUEST OF A MANUFACTURER, WHO SUBMITS PROPER SCIENTIFIC DATA AND EVIDENCE, BE GIVEN A HIGHER RATING BY THE BOILER CODE COMMITTEE THAN FOR FORGE WELDING, PROVIDED THAT AN AUTHORIZED INSPECTOR MAY DEMAND A TEST OF ANY ONE OF THE WELDED ARTICLES HE MAY SELECT FOR THE PURPOSE, AND IF, AFTER WITNESSING SUCH A TEST, HE SHALL DOUBT THE ADVISABILITY OF USING THE ASSIGNED RATING FOR THE WELD, THE CASE SHALL BE REFERRED TO THE BOILER CODE COMMITTEE FOR ITS DECISION.

PAR. P-193. REVISED:

P-193. In applying reinforcing plates to the drums of water-tube boilers to strengthen the shell where the tubes enter, they shall be riveted to the shell, and where outside calking is used, the tubes shall be expanded into the inner and outer plates so that the rivets and tubes will hold the plates together in accordance with the rules for stayed surfaces.

The spacing of the rivets with respect to the tubes shall conform to Par. P-199 for stayed surfaces, using a value of 135 for C, and shall be based on a unit pressure equal to the pressure that can be carried by the inner plate with a factor of safety of 5.

(NOTE: Where a reinforcing plate is inside the steam drum it is the inner plate; where it is outside and there is no inner reinforcing plate, the unreinforced shell of the drum is the inner plate.)

The tension in rivets and tubes shall conform to Pars. P-220 and P-232.

The combined drum shell and reinforcing plate or plates, and riveted connections, shall have a factor of safety of not less than 5 in the ligaments, when calculated in accordance with Par. P-192. When reinforcing plates or butt straps are exposed to flame or gas of the equivalent temperature, the joints shall be protected therefrom.

THE LARGEST DIAMETER OF UNREINFORCED CIRCULAR OPENING IN THE SHELL OF A DRUM SHALL NOT EXCEED 8 IN. IN ANY CASE, NOR SHALL IT EXCEED THE VALUES GIVEN BY THE FOLLOWING EQUATIONS WHEN SUCH VALUES ARE LESS THAN 8 IN.:

$$d = 1.154\,t\sqrt{\frac{S}{P}\left(\frac{1.0 - E}{E}\right)} \qquad (1)$$

or

$$d = \frac{1.154}{E}\sqrt{Rt\,(1.0 - E)} \qquad (2)$$

$$d' = \frac{d + L\left(\frac{1.0 - E}{E}\right)}{2} \qquad (3)$$

WHERE d = MAXIMUM DIAMETER OF UNREINFORCED CIRCULAR OPENING, IN., WHICH MAY EITHER BE SINGLE OR IN MULTIPLE ON A LINE PARALLEL TO THE AXIS OF THE DRUM AND SO SPACED THAT THE MINIMUM LIGAMENT EFFICIENCY, CONSIDERING ANY TWO HOLES, IS NOT LESS THAN THE MAXIMUM LONGITUDINAL JOINT OR LIGAMENT EFFICIENCY USED IN DETERMINING THE MAXIMUM ALLOWABLE WORKING PRESSURE OF THE DRUM.

d' = SAME AS d WITH THE EXCEPTION THAT THE PITCH OF THE HOLES ON ANY ONE ROW IS UNEQUAL (FOR EXAMPLE, PAR. P-192*b*).

t = MINIMUM THICKNESS OF SHELL PLATE.

S = ONE-FIFTH OF THE MINIMUM TENSILE STRENGTH STAMPED ON SHELL PLATES, LB. PER SQ. IN.

P = MAXIMUM ALLOWABLE WORKING PRESSURE, LB. PER SQ. IN.

E = EFFICIENCY OF LONGITUDINAL JOINT OR OF LIGAMENTS BETWEEN TUBE HOLES (WHICHEVER IS LEAST), OR THE RATIO OF THE STRESS IN THE SOLID PLATE, CIRCUMFERENTIALLY TO S.

R = THE INSIDE RADIUS OF THE WEAKEST COURSE OF THE SHELL OR DRUM, IN., PROVIDED THE THICKNESS OF THE SHELL DOES NOT EXCEED 10 PER CENT OF THE

RADIUS. IF THE THICKNESS IS OVER 10 PER CENT OF THE RADIUS, THE OUTER RADIUS SHALL BE USED FOR R.

L = THE DISTANCE ON THE CENTER LINE BETWEEN THE EDGES OF THE TWO HOLES WITH THE SMALLEST PITCH WHERE THE PITCH OF HOLES ON ANY ONE ROW IS UNEQUAL, IN.

PAR. P-197. REVISED:

P-197*A*. The corner-radius of an unstayed dished head measured on the concave side of the head shall not be less than 3 times the thickness of the material in the head; but in no case less than 6 per cent of the diameter of the shell.

[P-198] *B*. A flanged manhole opening in a dished head shall be flanged to a depth measured from the outside of the head at the major axis of not less than 3 times the required thickness of the head for plate up to $1^1/_2$ in. in thickness. For plate exceeding $1^1/_2$ in. in thickness the depth shall be the thickness of the plate plus 3 in. A manhole opening may be reinforced by a riveted manhole frame or other attachment in place of flanging.

PAR. P-198. REVISED:

FLAT HEADS

P-198. THE THICKNESS REQUIRED IN UNSTAYED FLAT HEADS, WHICH ARE UNPIERCED AND ARE RIGIDLY FIXED AND SUPPORTED AT THEIR BOUNDING EDGES BY RIVETED OR BOLTED ATTACHMENTS TO SHELLS OR SIDE PLATES, SHALL BE CALCULATED BY THE FOLLOWING FORMULA:

$$t = a\sqrt{\frac{0.145\,P}{S}}$$

WHERE t = THICKNESS OF PLATE IN HEAD, IN.

a = DIAMETER, OR SHORT SIDE OF AREA, IN.

P = MAXIMUM ALLOWABLE WORKING PRESSURE, LB. PER SQ. IN.

S = ALLOWABLE UNIT WORKING STRESS, LB. PER SQ. IN. = $\frac{TS}{5}$

TS = ULTIMATE TENSILE STRENGTH STAMPED ON SHELL PLATES, AS PROVIDED FOR IN THE SPECIFICATIONS FOR STEEL BOILER PLATE, LB. PER SQ. IN.

PAR. P-212*b*. REVISE FORMULA TO READ:

$$P = \frac{11{,}000t \times E}{R - \Sigma s \sin \alpha}$$

PAR. P-230*b*. REVISED:

b In a form of reinforcement for crown sheets where the top sheet of the firebox is a SEMI-CIRCLE AND THE TOP part of THE [a] circle not exceeding 120 deg. in arc is REINFORCED BY [braced with] arch bars extending over the top and down below the top row of staybolts at the sides of the FURNACE BENEATH THE SEMI-CIRCULAR crown sheet, these arch bars being riveted to the water side through thimbles, the maximum allowable working pressure should be determined by adding to the maximum allowable working pressure for a plain circular furnace of the same thickness, diameter, and length determined by the formula in Pars. P-239 and P-240, the pressure P_1 determined from the following formula which is a modification of that in Par. P-241*a*:

$$P_1 = 10{,}000{,}000\,\frac{b \times d^3}{D_1 \times D^2}$$

provided that the maximum allowable working pressure must not exceed that determined by the formula for furnaces of the Adamson type, in Par. P-242 when L is made equal to p, and also provided that the diameter of the holes for the staybolts in the crown bars does not exceed $^1/_3 b$, and the cross-sectional area of the crown bars is not less than 4 sq. in. Par. P-199 would govern the spacing of the staybolts, rivets, or bolts attaching the sheet to the bars, and Par. P-212*d* the size of the staybolts, rivets, or bolts

where b = net width of crown bar, in.

d = depth of crown bar, in.

D_1 = longitudinal pitch of crown bar, in.

D = 2 times radius of crown sheet.

FOR CONSTRUCTIONS IN WHICH THE CROWN SHEET IS NOT SEMI-CIRCULAR, A TEST TO DESTRUCTION SHALL BE MADE IN ACCORDANCE WITH PAR. P-247 AND THE WORKING PRESSURE BASED THEREON.

PAR. P-247. REVISED:

P-247. Where no rules are given and it is impossible to calculate with a reasonable degree of accuracy the strength of a boiler structure or any part thereof, a full-sized sample shall be built by the manufacturer and tested in ACCORDANCE WITH THE STANDARD PRACTICE FOR MAKING A HYDROSTATIC TEST ON A BOILER PRESSURE PART TO DETERMINE THE MAXIMUM ALLOWABLE WORKING PRESSURE, AS GIVEN IN THE APPENDIX [a manner to be prescribed by the Boiler Code Committee and in the presence of one or more representatives appointed to witness such test].

PAR. P-250. REVISED:

P-250. A fire-tube boiler shall have the ends of the tubes firmly rolled and beaded, or rolled, beaded, and welded around the edge of the bead. Where the tubes do not exceed $1^1/_2$ in. in diameter, the tube sheet may be chamfered or recessed to a depth at least equal to the thickness of the tubes and the tubes rolled into place and welded.

In no case shall THE DIAMETER OF THE FINISHED TUBE HOLE EXCEED THE NOMINAL DIAMETER OF THE TUBE BY GREATER THAN $^1/_{32}$ IN. AT THE FIRE END OR $^1/_{16}$ IN. AT THE OPPOSITE END OF THE TUBE, NOR the tube end extend more than $^3/_8$ in. beyond the tube sheet. In the case of tubes not exceeding $1^1/_2$ in. diameter, they may be expanded by the prosser method in place of rolling.

PAR. P-251. REVISED:

P-251. The ends of all tubes, suspension tubes, and nipples shall be expanded and flared not less than $^1/_8$ in. over the diameter of the tube hole on all water-tube boilers and superheaters, or they may be flared not less than $^1/_8$ in., rolled and beaded, or flared, rolled, and welded. IN NO CASE SHALL THE DIAMETER OF THE FINISHED TUBE HOLES EXCEED THE NOMINAL DIAMETER OF THE TUBES BY MORE THAN $^1/_{32}$ IN. Where pipe as provided in Par. P-21 is used for tubes in water-tube boilers, it may be screwed instead of rolled and flared, and the minimum number of threads shall conform to the values given in Table P-10. The closed ends of stub tubes shall be welded by the forging process.

PAR. P-268. REVISED:

NOZZLE OPENINGS

P-268. *Threaded Openings. a* All pipe threads shall conform to the American Pipe Thread Standard and all connections 1 in. pipe size or over shall have not less than the number of threads given in Table P-10. For smaller pipe connections there shall be at least four threads in the opening. If the thickness of the material in the boiler is not sufficient to give such number of threads, the opening shall be reinforced by RIVETING TO THE SHELL OR HEAD a pressed-steel, cast-steel, or bronze-composition flange, or plate, so as to provide AT LEAST the required number of threads.

FLANGES OR PADS WITH AT LEAST THE REQUIRED NUMBER OF THREADS MAY BE USED FOR THREADED OPENINGS, PROVIDED SAME ARE INSERTED FROM THE INSIDE OF THE SHELL AS SHOWN IN FIG. P-17 1/2 (A) OR SPHERICAL PORTION OF THE HEAD, SUCH PADS OR FLANGES TO HAVE A RETAINING FLANGE OR SHOULDER MACHINED OR FORMED TO THE INSIDE RADIUS OF THE SHELL OR HEAD, OR SUCH FLANGE OR SHOULDER TO REST AGAINST A FLAT SURFACE MACHINED ON THE INSIDE OF THE SHELL OR HEAD, THE RETAINING FLANGE OR SHOULDER TO BE OF SUFFICIENT STRENGTH TO RESIST THE STRESS DUE TO THE MAXIMUM ALLOWABLE WORKING PRESSURE WITH A FACTOR OF SAFETY OF 5, PROVIDED THE MAXIMUM CROSS-SECTION OF METAL REMOVED IN FORMING THE HOLE AND THE FLAT SURFACE IN A PLANE PASSING THROUGH THE OPENING AND THROUGH THE CENTER LINE OF THE SHELL DOES NOT EXCEED THAT ALLOWED BY THE RULES FOR UNREINFORCED CIRCULAR OPENINGS GIVEN IN PAR. P-193. SUCH OPENINGS MAY BE SEALED BY FUSION WELDING PROVIDED THE CARBON CONTENT OF THE STEEL DOES NOT EXCEED 0.30 PER CENT AND THE DIAMETER OF THE WELDED SEAL IS AT LEAST 1/2 IN. LESS THAN THE THE CARBON CONTENT OF THE STEEL DOES NOT EXCEED 0.30 PER CENT AND THE DIAMETER OF THE WELDED SEAL IS AT LEAST 1/2 IN. LESS THAN THE MAXIMUM DIAMETER ALLOWED BY THE RULES FOR UNREINFORCED CIRCULAR OPENINGS GIVEN IN PAR. P-193.

WHEN THE THICKNESS OF A SHELL OR THE SPHERICAL PORTION OF A HEAD IS GREATER THAN 3/4 IN., FORGED STEEL NOZZLES, THE OUTSIDE DIAMETER OF THE NECK OF WHICH DOES NOT EXCEED 4 1/2 IN., MAY BE ATTACHED THERETO BY INSERTING THROUGH AN OPENING AND EXPANDING INTO THE SHELL OR HEAD IN ACCORDANCE WITH THE REQUIREMENTS FOR SECURING BOILER TUBES; THE DIAMETER OF SUCH AN OPENING SHALL NOT EXCEED THAT GIVEN FOR UNREINFORCED CIRCULAR OPENINGS IN PAR. P-193.

ALL NOZZLES WHICH ARE FLARED OVER ON THE INSIDE OF THE SHELL OR HEAD, EXCEPT SMALL NOZZLES WHERE TUBE SEAT GROOVES ARE PROVIDED, MUST BE FORGED OR MACHINED WITH A SHOULDER WHICH RESTS ON A LOCALLY FLATTENED SURFACE ON THE OUTSIDE OF THE SHELL OR HEAD TO BE FORMED BY HOT FORGING, HOT FLANGING, OR MACHINING. WHEN THE OUTSIDE OF

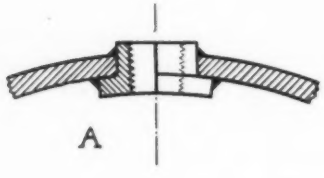

FIG. P-17 1/2 (A)

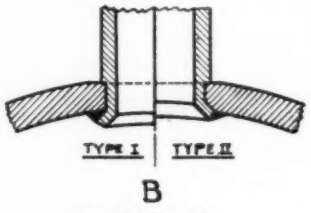

FIG. P-17 1/2 (B)

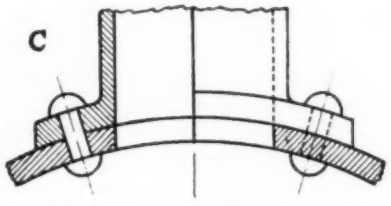

FIG. P-17 1/2 (C)

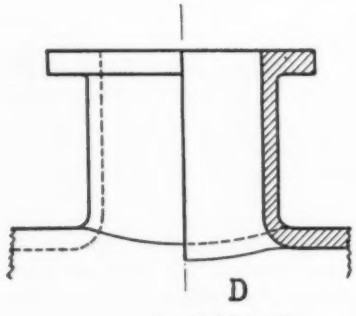

FIG. P-17 1/2 (D)

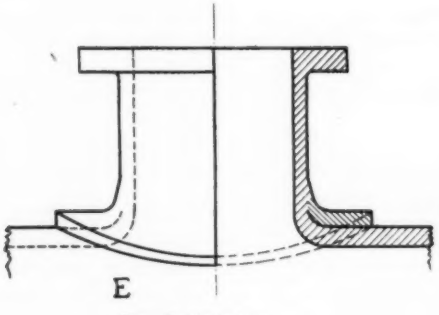

FIG. P-17 1/2 (E)

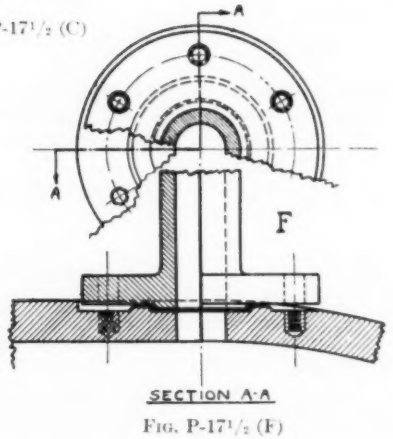

FIG. P-17 1/2 (F)

MAXIMUM DIAMETER ALLOWED BY THE RULES FOR UNREINFORCED CIRCULAR OPENINGS GIVEN IN PAR. P-193.

When the maximum allowable working pressure exceeds 100 lb. per sq. in., OPENINGS [outlet connections] over 3 in. pipe size shall not have screwed joints, but flanged fittings shall be used, EXPANDED, riveted, OR FORGE WELDED directly to the shell or head, or a fitting with a raised flat face on the boiler side OF THE FITTING may be connected directly to the boiler or head of the boiler by means of studs, ALL AS HEREINAFTER SPECIFIED.

FLANGED FITTINGS, FLARED OR EXPANDED CONNECTIONS. *b* ON SHELLS AND SPHERICAL PORTIONS OF THE HEADS, FORGED STEEL NOZZLES SUCH AS SHOWN IN FIG. P-17 1/2 (B) MAY BE INSERTED THROUGH AN OPENING, FLARED OVER ON THE INSIDE TO AN AMOUNT EQUAL TO AT LEAST THE THICKNESS OF THE NECK OF THE NOZZLE UP TO AN OUTSIDE DIAMETER WHICH SHALL NOT EXCEED THAT GIVEN FOR UNREINFORCED CIRCULAR OPENINGS IN PAR. P-193. THE DIAMETER OF THE OPENING SHALL NOT BE MORE THAN 1/32 IN. GREATER THAN THE OUTSIDE DIAMETER OF THE PART OF THE NOZZLE WHICH PASSES THROUGH THE SHELL. SUCH NOZZLES MAY BE SEALED BY FUSION WELDING PROVIDED SHELL OR HEAD IS MACHINED, THE MAXIMUM CROSS-SECTION OF THE METAL REMOVED IN A PLANE PASSING THROUGH THE OPENING AND THROUGH THE CENTER LINE OF THE DRUM SHALL NOT EXCEED THAT ALLOWED BY THE RULES FOR UNREINFORCED CIRCULAR OPENINGS GIVEN IN PAR. P-193.

FLANGED FITTINGS, RIVETED CONNECTIONS. *c* WHEN FLANGED FITTINGS ARE RIVETED DIRECTLY TO THE SHELL OR THE SPHERICAL PORTION OF THE HEAD AS SHOWN IN FIG. P-17 1/2 (C), THE CONNECTION SHALL BE DESIGNED IN ACCORDANCE WITH THE RULES FOR MANHOLES IN PARS. P-260 AND P-261.

FLANGED FITTINGS, FORGE-WELDED. *d* NOZZLES MAY BE FORGE WELDED, WITH OR WITHOUT REINFORCEMENT, TO THE SHELL OR TO THE SPHERICAL PORTIONS OF THE HEAD. (SEE FIG. P-17 1/2 (D).) WHEN THE INSIDE DIAMETER OF THE VESSEL IS 36 IN. OR GREATER, THE INSIDE DIAMETER OF UNREINFORCED FORGE-WELDED NOZZLE SHALL NOT EXCEED THAT GIVEN IN THE FOLLOWING EQUATION:

$$d = 0.1155 \frac{D}{E} \sqrt{6E - 5E^2 - 1}$$

WHERE d = MAXIMUM ALLOWABLE DIAMETER OF OPENING IN NOZZLE, IN IN.

D = INSIDE DIAMETER OF SHELL, IN IN.

$E = \frac{\text{COMPUTED STRESS IN SOLID PLATE}}{\text{MAXIMUM ALLOWABLE STRESS}}$

FORGE-WELDED NOZZLES WHICH REQUIRE REINFORCEMENT MAY BE OF THE REINFORCED TYPE AS DESCRIBED IN PAR. P-195 AND SHOWN IN FIG. P-17$^1/_2$ (E); THE THICKNESS OF THE REINFORCING PAD SHALL NOT BE LESS THAN THAT GIVEN IN THE FOLLOWING EQUATION:

$$t = T\left[3.75\frac{d}{D} - 0.525\frac{(1-E)}{E}\right]$$

WHERE t = REQUIRED THICKNESS OF PAD, IN IN.

T = THICKNESS OF SHELL OR HEAD, IN IN.

d = INSIDE DIAMETER OF NOZZLE, IN IN.

D = INSIDE DIAMETER OF SHELL, IN IN.

$E = \frac{\text{COMPUTED STRESS IN SOLID PLATE}}{\text{MAXIMUM ALLOWABLE STRESS}}$

THE THICKNESS OF THE REINFORCING PAD SHALL NOT BE LESS THAN $^3/_4$ IN. WHEN THICKNESS OF SHELL OR HEAD TO WHICH SAME IS FITTED IS 2 IN. OR LESS. WHEN THICKNESS OF HEAD OR SHELL IS GREATER THAN 2 IN., THE MINIMUM THICKNESS OF THE PAD SHALL BE 1 IN. THE WIDTH OF THE PAD ALONG THE LONGITUDINAL AXIS OF THE SHELL SHALL NOT BE LESS THAN THE INSIDE RADIUS OF THE NOZZLE OPENING.

FLANGED FITTINGS, STUD-BOLTED CONNECTION. *e* A STUDDED CONNECTION OF THE TYPE SHOWN IN FIG. P-17$^1/_2$ (F) MAY BE USED FOR ATTACHING OUTLETS TO SHELLS OR SPHERICAL PORTIONS OF HEADS WITH A FLAT SURFACE MACHINED ON THE SHELL OR HEAD FOR A GASKET PROVIDED THE AREA OF THE MAXIMUM CROSS-SECTION OF THE METAL REMOVED FROM THE SHELL OR HEAD IN FORMING THE HOLE AND THE FLAT SURFACE AND IN TAPPING FOR THE STUD BOLTS, FOR ANY PLANE PASSING THROUGH THE OPENING AND THROUGH THE CENTER LINE OF THE DRUM, DOES NOT EXCEED THAT CORRESPONDING TO A CIRCULAR HOLE THROUGH THE SHELL OF THE MAXIMUM DIAMETER ALLOWED BY THE RULES FOR UNREINFORCED CIRCULAR OPENINGS GIVEN IN PAR. P-193. THE DIMENSIONS OF THE FLANGE OF THE STUDDED CONNECTION SHALL CONFORM TO THOSE GIVEN IN TABLE A-5*b*. THE STUDS SHALL CONFORM TO THE DIMENSIONS FOR BOLTS GIVEN IN TABLE A-5*b* AND SHALL BE SPACED AS DESIGNATED IN THIS TABLE. THE NET THICKNESS OF THE SHELL OR HEAD MUST BE AT LEAST EQUAL TO THE TOTAL DIAMETERS GIVEN IN TABLE A-5*b*. STUD HOLES SHALL STRADDLE THE CENTER LINE OF THE DRUM.

[If studs are used they must be not less than $^3/_4$ in. diameter and must have not less than ten threads per inch. The thickness of the boiler plate must be not less than the diameter of the studs. The allowable tensile stress on these studs must not exceed the stresses indicated by the bolted connections given in Table A-6.]

PAR. I-32. ADD THE FOLLOWING:

b TOLERANCES FOR ELLIPSOIDAL HEADS. HEADS OF ELLIPSOIDAL FORM SHALL BE CHECKED FOR THEIR CONFORMITY TO THE TRUE ELLIPTICAL SHAPE. THE MANUFACTURER OF SUCH HEADS SHALL FURNISH THE INSPECTOR WITH A TEMPLATE MADE OF WOOD OR METAL WHICH MUST BE MADE AS NEARLY EXACT, TRUE SEMI-ELLIPTICAL AS PRACTICABLE. THE TOTAL TOLERANCE AT POINTS "A" OR "B" IN FIG. I-2 SHALL NOT EXCEED $1^1/_4$ PER CENT OF THE INSIDE DIAMETER OF THE HEAD.

PAR. L-43*b*. REVISE FORMULA TO READ:

$$P = \frac{55{,}000}{FS} \times \frac{t \times E}{R - \Sigma s \sin \alpha}$$

PAR. U-38. REVISED:

U-38 *A*. The corner radius of an unstayed dished head measured on the concave side of the head shall not be less than 3 times the thickness of the material in the head; but in no case less than 6 per cent of the diameter of the shell.

[U-39] *B*. A flanged manhole opening in a dished head shall be flanged to a depth measured from the outside of the head at the major axis of not less than 3 times the required thickness of the head for plate up to $1^1/_2$ in. in thickness. For plate exceeding $1^1/_2$ in., the depth shall be the thickness of the plate plus 3 in. A manhole opening may be reinforced by a riveted manhole frame or other attachment in place of flanging.

PAR. U-39. REVISED:

FLAT HEADS

U-39. THE THICKNESS REQUIRED IN UNSTAYED FLAT HEADS, WHICH ARE UNPIERCED AND ARE RIGIDLY FIXED AND SUPPORTED

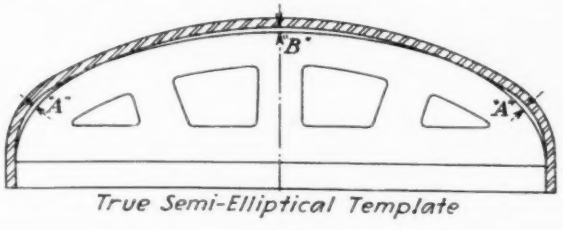

FIG. I-2

AT THEIR BOUNDING EDGES BY RIVETED OR BOLTED ATTACHMENTS TO SHELLS OR SIDE PLATES, SHALL BE CALCULATED BY THE FOLLOWING FORMULA:

$$t = a\sqrt{\frac{0.145\,P}{S}}$$

WHERE t = THICKNESS OF PLATE IN HEAD, IN.

a = DIAMETER, OR SHORT SIDE OF AREA, IN.

P = MAXIMUM ALLOWABLE WORKING PRESSURE, LB. PER SQ. IN.

S = ALLOWABLE UNIT WORKING STRESS, LB. PER SQ. IN. = $\frac{TS}{5}$

TS = ULTIMATE TENSILE STRENGTH STAMPED ON SHELL PLATES, AS PROVIDED FOR IN THE SPECIFICATIONS FOR STEEL BOILER PLATE, LB. PER SQ. IN.

PAR. U-59. REVISED: NOZZLE OPENINGS

U-59. *Threaded Openings. a* All pipe threads shall conform to the American Pipe Thread Standard and all connections 1 in. pipe size or over shall have not less than the number of threads given in Table U-5. For smaller pipe connections there shall be at least four threads in the openings. If the thickness of the material in the pressure vessel is not sufficient to give such number of threads, the opening shall be reinforced by a pressed-steel, cast-steel, or bronze-composition flange, or plate, riveted or brazed on, or a boss may be built up by an autogenous welding process for an opening not to exceed 2 in. pipe size and for a pressure not to exceed 100 lb. per sq. in., so as to provide AT LEAST the required number of threads.

FLANGES OR PADS WITH AT LEAST THE REQUIRED NUMBER OF THREADS MAY BE USED FOR THREADED OPENINGS, PROVIDED SAME ARE INSERTED FROM THE INSIDE OF THE SHELL OR SPHERICAL PORTIONS OF THE HEAD AS SHOWN IN FIG. U-2$^1/_2$ (A),[1] SUCH PADS OR FLANGES TO HAVE A RETAINING FLANGE OR SHOULDER MA-

[1] Same illustration as Fig. P-17$^1/_2$ (A).

CHINED OR FORMED TO THE INSIDE RADIUS OF THE SHELL OR HEAD, OR SUCH FLANGE OR SHOULDER TO REST AGAINST A FLAT SURFACE MACHINED ON THE INSIDE OF THE SHELL OR HEAD, THE RETAINING FLANGE OR SHOULDER TO BE OF SUFFICIENT STRENGTH TO RESIST THE STRESS DUE TO THE MAXIMUM ALLOWABLE WORKING PRESSURE WITH A FACTOR OF SAFETY OF 5, PROVIDED THE MAXIMUM CROSS-SECTION OF METAL REMOVED IN FORMING THE HOLE AND THE FLAT SURFACE IN A PLANE PASSING THROUGH THE OPENING AND THROUGH THE CENTER LINE OF THE SHELL DOES NOT EXCEED THAT ALLOWED FOR AN UNREINFORCED CIRCULAR OPENING OF A DIAMETER DETERMINED BY THE FORMULAS GIVEN BELOW. SUCH OPENINGS MAY BE SEALED BY FUSION WELDING PROVIDED THE CARBON CONTENT OF THE STEEL IN THE SHELL DOES NOT EXCEED 0.30 PER CENT AND THE DIAMETER OF THE WELDED SEAL IS AT LEAST $^1/_2$ IN. LESS THAN THE MAXIMUM DIAMETER ALLOWED FOR AN UNREINFORCED CIRCULAR OPENING, AS GIVEN IN THE FORMULAS BELOW.

THE DIAMETER OF AN UNREINFORCED OPENING FOR A THREADED OUTLET SHALL NOT EXCEED 8 IN. IN ANY CASE, NOR SHALL IT EXCEED THE VALUES GIVEN BY THE FOLLOWING EQUATIONS WHEN SUCH VALUES ARE LESS THAN 8 IN.:

$$d = 1.154\,t\sqrt{\frac{S}{P}\left(\frac{1.0 - E}{E}\right)} \qquad (1)$$

OR

$$d = \frac{1.154}{E}\sqrt{Rt\,(1.0 - E)} \qquad (2)$$

$$d' = \frac{d + L\left(\frac{1.0 - E}{E}\right)}{2} \qquad (3)$$

WHERE d = MAXIMUM DIAMETER OF UNREINFORCED CIRCULAR OPENING, IN., WHICH MAY EITHER BE SINGLE OR IN MULTIPLE ON A LINE PARALLEL TO THE AXIS OF THE DRUM AND SO SPACED THAT THE MINIMUM LIGAMENT EFFICIENCY, CONSIDERING ANY TWO HOLES, IS NOT LESS THAN THE MAXIMUM LONGITUDINAL JOINT OR LIGAMENT EFFICIENCY USED IN DETERMINING THE MAXIMUM ALLOWABLE WORKING PRESSURE OF THE DRUM.

d' = SAME AS d WITH THE EXCEPTION THAT THE PITCH OF THE HOLES ON ANY ONE ROW IS UNEQUAL.

t = MINIMUM THICKNESS OF SHELL PLATE.

S = ONE-FIFTH OF THE MINIMUM TENSILE STRENGTH STAMPED ON SHELL PLATE, LB. PER SQ. IN.

P = MAXIMUM ALLOWABLE WORKING PRESSURE, LB. PER SQ. IN.

E = EFFICIENCY OF LONGITUDINAL JOINT OR OF LIGAMENTS BETWEEN TUBE HOLES (WHICHEVER IS THE LEAST), OR THE RATIO OF THE STRESS IN THE SOLID PLATE, CIRCUMFERENTIALLY TO S.

R = THE INSIDE RADIUS OF THE WEAKEST COURSE OF THE SHELL OR DRUM, IN., PROVIDED THE THICKNESS OF THE SHELL DOES NOT EXCEED 10 PER CENT OF THE RADIUS. IF THE THICKNESS IS OVER 10 PER CENT OF THE RADIUS, THE OUTER RADIUS SHALL BE USED FOR R.

L = THE DISTANCE ON THE CENTER LINE BETWEEN THE EDGES OF THE TWO HOLES WITH THE SMALLEST PITCH WHERE THE PITCH OF HOLES ON ANY ONE ROW IS UNEQUAL, IN.

When the maximum allowable working pressure exceeds 100 [125] lb. per sq. in., AND THE SHELL THICKNESS IS LESS THAN $^3/_4$ IN., [all pipe] openings over 3-in. pipe size shall NOT HAVE SCREWED JOINTS, BUT FLANGED FITTINGS SHALL BE USED, EXPANDED, RIVETED, OR FORGE WELDED DIRECTLY TO THE SHELL OR HEAD, OR A FITTING WITH A RAISED FLAT FACE ON THE PRESSURE VESSEL SIDE OF THE FITTING MAY BE CONNECTED DIRECTLY TO THE PRESSURE VESSEL OR HEAD OF THE VESSEL BY MEANS OF STUDS, ALL AS HEREINAFTER SPECIFIED. [be provided with a flanged fitting adapted to receive a pipe flange and which may be attached to the pressure vessel by riveting, brazing, or any of the methods of welding prescribed in this section of the code. For pressures less than 125 lb. per sq. in. a screwed fitting may be used.]

FLANGED FITTINGS, FLARED OR EXPANDED CONNECTIONS. *b* ON SHELLS AND THE SPHERICAL PORTIONS OF THE HEADS, FORGED STEEL NOZZLES AS SHOWN IN FIG. U-$2^1/_2$ (B)[2] MAY BE INSERTED THROUGH AN OPENING, FLARED OVER ON THE INSIDE TO AN AMOUNT EQUAL TO AT LEAST THE THICKNESS OF THE NECKS OF THE NOZZLE UP TO AN OUTSIDE DIAMETER WHICH SHALL NOT EXCEED THAT GIVEN FOR UNREINFORCED CIRCULAR OPENINGS IN THE FORMULAS ABOVE. THE DIAMETER OF THE OPENING SHALL NOT BE MORE THAN $^1/_{32}$ IN. GREATER THAN THE OUTSIDE DIAMETER OF THE PART OF THE NOZZLE WHICH PASSES THROUGH THE SHELL. SUCH NOZZLES MAY BE SEALED BY FUSION WELDING PROVIDED THE CARBON CONTENT OF THE STEEL DOES NOT EXCEED 0.30 PER CENT AND THE DIAMETER OF THE WELDED SEAL IS AT LEAST $^1/_2$ IN. LESS THAN THE MAXIMUM DIAMETER GIVEN FOR UNREINFORCED CIRCULAR OPENINGS IN THE FORMULAS ABOVE.

WHEN THE THICKNESS OF A SHELL OR THE SPHERICAL PORTION OF A HEAD IS GREATER THAN $^3/_4$ IN., FORGED-STEEL NOZZLES, THE OUTSIDE DIAMETER OF THE NECK OF WHICH DOES NOT EXCEED $4^1/_2$ IN., MAY BE ATTACHED THERETO BY INSERTING THROUGH AN OPENING AND EXPANDING INTO THE SHELL OR HEAD IN ACCORDANCE WITH THE REQUIREMENTS FOR SECURING BOILER TUBES; THE DIAMETER OF SUCH AN OPENING SHALL NOT EXCEED THAT GIVEN FOR UNREINFORCED CIRCULAR OPENINGS IN THE FORMULAS ABOVE.

ALL NOZZLES WHICH ARE FLANGED OVER ON THE INSIDE OF THE SHELL OR HEAD, EXCEPT SMALL NOZZLES WHERE TUBE SEAT GROOVES ARE PROVIDED, MUST BE FORGED OR MACHINED WITH A SHOULDER WHICH RESTS ON A LOCALLY FLATTENED SURFACE ON THE OUTSIDE OF THE SHELL OR HEAD, TO BE FORMED BY HOT-FORGING, HOT-FLANGING, OR MACHINING. WHEN THE OUTSIDE OF SHELL OR HEAD IS MACHINED, THE MAXIMUM CROSS-SECTION OF THE METAL REMOVED IN A PLANE PASSING THROUGH THE OPENING AND THROUGH THE CENTER LINE OF THE DRUM SHALL NOT EXCEED THAT ALLOWED BY THE RULES FOR UNREINFORCED CIRCULAR OPENINGS GIVEN ABOVE.

FLANGED FITTINGS, RIVETED CONNECTION. *c* WHEN FLANGED FITTINGS ARE RIVETED DIRECTLY TO THE SHELL OR THE SPHERICAL PORTIONS OF THE HEAD AS SHOWN IN FIG. U-$2^1/_2$ (C),[3] THE CONNECTION SHALL BE DESIGNED IN ACCORDANCE WITH THE RULES FOR MANHOLES IN PARS. U-55, U-56, AND U-57.

FLANGED FITTINGS, FORGE-WELDED. *d* NOZZLES MAY BE FORGE-WELDED, WITH OR WITHOUT REINFORCEMENT, TO THE SHELL OR TO THE SPHERICAL PORTIONS OF THE HEADS AS PERMITTED IN PAR. U-88.

FLANGED FITTINGS, STUD-BOLTED CONNECTION. *e* A STUDDED CONNECTION OF THE TYPE SHOWN IN FIG. U-$2^1/_2$ (D)[4] MAY BE USED FOR ATTACHING OUTLETS TO SHELLS OR SPHERICAL PORTIONS OF HEADS WITH A FLAT SURFACE MACHINED ON THE SHELL OR HEAD FOR A GASKET PROVIDED THE AREA OF THE MAXIMUM CROSS-SECTION OF THE METAL REMOVED FROM THE SHELL OR HEAD IN FORMING THE HOLE AND THE FLAT SURFACE AND IN TAPPING FOR THE STUD BOLTS, FOR ANY PLANE PASSING THROUGH

[2] Same illustration as Fig. P-$17^1/_2$ (B).
[3] Same illustration as Fig. P-$17^1/_2$ (C).
[4] Same illustration as Fig. P-$17^1/_2$ (D).

THE OPENING AND THROUGH THE CENTER LINE OF THE DRUM, DOES NOT EXCEED THAT CORRESPONDING TO A CIRCULAR HOLE THROUGH THE SHELL OF THE MAXIMUM DIAMETER ALLOWED BY THE RULES FOR UNREINFORCED CIRCULAR OPENINGS GIVEN IN PAR. P-193. THE DIMENSIONS OF THE FLANGE OF THE STUDDED CONNECTION SHALL CONFORM TO THOSE GIVEN IN TABLE A-5*b*. THE STUDS SHALL CONFORM TO THE DIMENSIONS FOR BOLTS GIVEN IN TABLE A-5*b* AND SHALL BE SPACED AS DESIGNATED IN THIS TABLE. THE NET THICKNESS OF THE SHELL OR HEAD MUST BE AT LEAST EQUAL TO THE TOTAL DIAMETERS GIVEN IN TABLE A-5*b*. STUD HOLES SHALL STRADDLE THE CENTER LINE OF THE DRUM.

PAR. U-65. REVISED:

U-65. Every pressure vessel shall be inspected at least TWICE [once] by a state or municipal inspector of boilers, or an inspector employed regularly by an insurance company which is authorized to do a boiler-insurance business in the state in which the vessel is built, or in the state in which it is to be used, if known, which inspections shall be made ONE BEFORE REAMING RIVET HOLES OR FINALLY CLOSING THE VESSEL TO INSPECTION, AND THE OTHER when the hydrostatic pressure test is on. A data sheet shall be filled out and signed by the manufacturer and the inspector, which data sheet, together with the stamping on the vessel, will denote that it is constructed in accordance with these Rules. Every pressure vessel fabricated in whole or in part by a welding process, shall, when the size of the shell permits, be internally inspected before being finally closed to inspection.

PAR. U-88. REVISED:

U-88. *Inlet and Outlet Connections.* Pipe connections may be made as provided for in Par. U-59.

Nozzles which are attached by forge welding shall be of forged or rolled steel material, seamless tubing or forge-welded pipe, using either of the three methods shown at (*B*), Fig. U-4, or attached to a head by forge welding as shown at (*A*), Fig. U-4. Either the nozzle or shell may be flared for this purpose.

NOZZLES MAY BE FORGE-WELDED, WITH OR WITHOUT REINFORCEMENT, TO THE SHELL OR TO THE SPHERICAL PORTIONS OF THE HEAD (SEE FIG. U-4$^1/_2$ (A)).[5] WHEN THE INSIDE DIAMETER OF THE VESSEL IS 36 IN. OR GREATER, THE INSIDE DIAMETER OF AN UNREINFORCED FORGE-WELDED NOZZLE SHALL NOT EXCEED THAT GIVEN IN THE FOLLOWING EQUATION:

$$d = 0.1155 \frac{D}{E} \sqrt{6E - 5E^2 - 1}$$

WHERE d = MAXIMUM ALLOWABLE INSIDE DIAMETER OF NOZZLE, IN IN.

D = INSIDE DIAMETER OF SHELL, IN IN.

E = COMPUTED STRESS IN SOLID PLATE / MAXIMUM ALLOWABLE STRESS

FORGE-WELDED NOZZLES WHICH REQUIRE REINFORCEMENT MAY BE OF THE REINFORCED TYPE AS DESCRIBED IN PAR. U-36 AND SHOWN IN FIG. U-4$^1/_2$ (B).[6] THE THICKNESS OF THE REINFORCING PAD MAY NOT BE LESS THAN THAT GIVEN IN THE FOLLOWING EQUATION:

$$t = T\left[3.75 \frac{d}{D} - 0.525 \frac{(1 - E)}{E}\right]$$

WHERE t = REQUIRED THICKNESS OF PAD, IN IN.

T = THICKNESS OF SHELL OR HEAD, IN IN.

d = INSIDE DIAMETER OF NOZZLE, IN IN.

D = INSIDE DIAMETER OF SHELL, IN IN.

E = COMPUTED STRESS IN SOLID PLATE / MAXIMUM ALLOWABLE STRESS

THE THICKNESS OF THE REINFORCING PAD SHALL NOT BE LESS THAN $^3/_4$ IN. WHEN THE THICKNESS OF SHELL OR HEAD TO WHICH THE SAME IS FITTED IS 2 IN. OR LESS; WHEN THICKNESS OF HEAD OR SHELL IS GREATER THAN 2 IN., THE MINIMUM THICKNESS OF THE PAD SHALL BE 1 IN. THE WIDTH OF THE PAD ALONG THE LONGITUDINAL AXIS OF THE SHELL SHALL NOT BE LESS THAN THE INSIDE RADIUS OF THE NOZZLE OPENING.

[5] Same illustration as Fig. P-17$^1/_2$ (D).

[6] Same illustration as Fig. P-17$^1/_2$ (E).

Correspondence

CONTRIBUTIONS to the Correspondence Department of Mechanical Engineering are solicited. Contributions particularly welcomed at all times are discussions of papers published in this journal, brief articles of current interest to mechanical engineers, or comments from members of The American Society of Mechanical Engineers on its activities or policies in Research and Standardization.

Coordination of Industrial-Plant and Central-Station Power

IN HIS paper on "Coordination of Industrial Plant and Central Station Power" (FSP-51-16) P. J. Gaudy makes the following rather categorical statements:

> "An industrial can generate electric energy for power purposes profitably only when one of the following conditions is satisfied: The utility must be inadequate to maintain proper service or be operating under conditions which do not make possible a reasonable power rate, or the industrial must have energy in some form available for conversion to power which is a by-product or natural result of its major manufacturing processes."

and again

> "Industrial power cannot be generated under usual conditions with economy to the industrial unless:
> 1 The rates are inordinately high
> 2 The supply is inadequate or irresponsible
> 3 The by-products of manufacture contain an element of energy which is not usable
> 4 The manufacturing processes inherently contain energy uses which do not exhaust the power possibilities of the medium."

In making these statements, the author must have confined his thoughts to *steam* power plants, for he has apparently overlooked the fact that industrial power generated by Diesel engines does not conform at all to the rules he has set up. Among the hundreds of industrial plants that are generating electric energy profitably with Diesel engines are many where electric rates are moderate, where purchased power is reliable and where no by-products of manufacture are used.

The reasons why a small Diesel power plant can often generate industrial power cheaper than a public utility can sell it are because a small Diesel plant enjoys a far higher thermal efficiency than any steam central station and because locally generated power is free of the large expense for transmission and distribution that greatly increases the delivered cost of central-station current.

EDGAR J. KATES.[1]

New York, N. Y.

[1] Consulting Engineer. Mem. A.S.M.E.

Engineering and Industrial Standardization

Questionnaire on Machine-Taper Series

FOR a number of months a broadly representative Committee has been at work endeavoring to develop a proposal for an American Standard on Machine Tapers. Numerous proposals have been presented, discussed, and discarded. The members of the Committee are at present divided in opinion as to whether they should recommend the adoption of a new series of tapers with an angle or slope of 0.750 in. per ft. or whether they should recommend a similar series in which the Morse tapers Nos. 1 to 5, inclusive, replace the corresponding tapers in the other series.

A questionnaire has been prepared, accordingly, for distribution to interested firms and individuals representing manufacturers, dealers, and users of machine tapers for advice before making its decision. This questionnaire includes detailed dimensions of each of the proposed series and a sheet of explanatory notes prepared by the Committee which give arguments in favor of the adoption of each of these series. These notes and dimensions of the two series are reprinted below.

Explanatory Notes

A Suggested New Series of Tapers With 0.750 In. per Ft. Slope or Angle

1 The 0.750-in. per ft. taper has capacity for greater end pressure, and also allows tools to be more readily freed from sockets. In many cases Morse tapers stick too tight because of small angle. In other cases, the holding power is not enough. A simple locking means should be used in such cases, so the 0.750-in. taper is at no disadvantage over Morse taper in that respect.

2 Small tools and portable tools are comparatively short-lived, and stocks could be worked out in a short time in these days of quick stock turnover. While the transition period would entail some relatively small hardship on producers and dealers, the change would greatly benefit the user, who has the biggest interest in the solution of the problem, and in the long run would also benefit the producer.

3 The slight cost of changing the taper in many existing machine spindles would soon be covered by the advantages of the new taper. Modern rapid obsolescence of machine tools in general makes the transition period short; that cannot be changed.

4 It is best to have only one series with one angle, for making tools like boring bars, instead of the five angles involved in the other proposal. In many shops the self-made boring bars, etc., represent a larger investment than the purchased small tools.

5 A taper satisfactory for one size is obviously correct for all other sizes, since holding power of a taper is directly proportional to force with which it is driven into the socket.

6 A 0.750-in. per ft. taper is enough steeper than all others to prevent inadvertent interchanging with any other, to the damage of tools or machines as is now possible.

7 Ratio being 1 to 16 it lends itself well to the inch system of measurement. Diameters at large end increase in easily remembered fractions of inch, providing simplicity of numbering, gaging, and manufacturing.

8 The new No. 00 and 0 tapers, proposed at 0.600 in. per ft. in the second proposal, will be confused with the original Morse 0 which had 0.625 taper. The new No. 0 will be confused with Morse No. 0, through carrying the same number for a different taper.

A Suggested Series of Tapers Including Morse Tapers Nos. 1 to 5

1 Morse Tapers Nos. 1, 2, 3, 4, and 5 have proved satisfactory and have attained acceptance through use abroad. An extremely large proportion of taper shanks on small tools now in use are Morse. It might prove to be an economic waste to replace them with new tapers that could not be better.

2 Elimination of Morse tapers would cause great hardships to manufacturers, dealers, and consumers of small tools all over the world.

3 Eliminating Morse tapers would present difficulties where headroom is limited, as in drill presses, and in other places where adapters cannot be used, as in portable electric and pneumatic tools. The cost of changing these spindles would be considerable without compensating advantages.

4 While several taper angles are included in Morse series, this has not proved to be any serious difficulty in manufacture. Any shop that makes any taper tools or sockets must have standard gages, and when gages are used a knowledge of the actual angle is of no importance.

5 The holding power of Morse tapers is better than that of 0.750-in. per ft. taper, in small sizes, and it is within this range where by far the greater number are used.

6 Tools of all descriptions such as drills, end mills, ct. bores, etc., which now have the Morse taper can readily be used in other types of machines, such as milling machines, lathes, etc., which at present cannot be done without damage to tool or machines on account of the many varieties of tapers.

7 Even though the single series (0.750 in. per ft.) were somewhat superior to the five-angle series of this proposal, some seriously question if its advantages would compensate for the practical disadvantages caused by elimination of the Morse tapers.

A SUGGESTED SERIES OF TAPERS WITH 0.750 IN. PER FT. SLOPE OR ANGLE

Taper No., In.	Diam. Large End	Diam. Small End	Plug Depth	Ratio Length to Diam.	Taper, In. per Ft.
1/4	0.250	0.188	1.000	4.00	0.750
3/8	0.375	0.281	1.500	4.00	0.750
1/2	0.500	0.375	2.000	4.00	0.750
3/4	0.750	0.586	2.625	3.50	0.750
1	1.000	0.797	3.250	3.25	0.750
1 1/4	1.250	1.016	3.750	3.00	0.750
1 1/2	1.500	1.227	4.375	2.92	0.750
1 3/4	1.750	1.445	4.875	2.79	0.750
2	2.000	1.656	5.500	2.75	0.750
2 1/2	2.500	2.086	6.625	2.65	0.750
3	3.000	2.516	7.750	2.58	0.750
4	4.000	3.375	10.000	2.50	0.750
5	5.000	4.242	12.125	2.43	0.750
6	6.000	5.102	14.375	2.40	0.750
8	8.000	6.820	18.875	2.36	0.750
10	10.000	8.547	23.250	2.33	0.750
12	12.000	10.273	27.625	2.30	0.750

Plug Depth

Diameter Large End = D
From 0.250 to 0.500 = 4D
Above 0.500 = 2.20 plus $\sqrt[10]{D}$ to nearest 0.125

A SUGGESTED SERIES OF TAPERS INCLUDING MORSE TAPERS NO. 1 TO 5

Taper No.	Diam. Large End	Diam. Small End	Plug Depth	Ratio Length to Diam.	Taper, In. per Foot
00	0.250	0.200	1.000	4.00	0.600
0	0.375	0.300	1.500	4.00	0.600
1[1]	0.475	0.369	2.125	4.47	0.600
2[1]	0.700	0.572	2.562	3.66	0.602
3[1]	0.938	0.778	3.187	3.40	0.602
4[1]	1.231	1.020	4.062	3.30	0.623
4 1/2	1.500	1.475	4.375	2.92	0.623
5[1]	1.748	1.475	5.187	2.97	0.630
16	2.000	1.656	5.500	2.75	0.750
20	2.500	2.086	6.625	2.65	0.750
24	3.000	2.516	7.750	2.58	0.750
32	4.000	3.375	10.000	2.50	0.750
40	5.000	4.242	12.125	2.43	0.750
48	6.000	5.102	14.375	2.40	0.750
64	8.000	6.820	18.875	2.36	0.750
80	10.000	8.547	23.250	2.33	0.750
96	12.000	10.273	27.625	2.30	0.750

[1] Present Morse tapers (no change).

Plug Depth

Diameter Large End = D
From 0.250 to 3.75 = $4D$
0.475, 0.700, 0.938, 1.231 and 1.748 = Present Morse Standard.
1.500 and above 1.748 = $2.2D$ plus $\sqrt[10]{D}$ to nearest 0.125.

If, after a careful review of this material, any of our readers care to express their opinions on this subject they will be greatly appreciated by the Technical Committee. In fact, the Committee would be glad if all interested readers of this article would indicate their choice of one of the two series of machine tapers at the same time giving their reasons. Communications should be addressed to E. F. DuBrul, Chairman, Technical Committee No. 3, care of A.S.M.E.

The Conference Table

THIS Department is intended to afford individual members of the Society an opportunity to exchange experience and information with other members. It is to be understood, however, that questions which should properly be referred to a consulting engineer will not be handled in this department.

Inquiries will be welcomed at Society headquarters, where they will be referred to representatives of the various Professional Divisions of the Society for consideration. Replies are solicited from all members having experience with the questions indicated. Replies should be as brief as possible. Among those who have consented to assist in this work are the following:

ARCHIBALD BLACK,
Aeronautic Division
A. L. KIMBALL, JR.,
Applied Mechanics Division
H. W. BROOKS,
Fuels Division
R. L. DAUGHERTY,
Hydraulic Division
WM. W. MACON,
Iron and Steel Division
JAMES A. HALL,
Machine-Shop Practice Division
CHARLES W. BEESE,
Management Division
G. E. HAGEMANN,
Materials Handling Division
J. L. WALSH,
National Defense Division
L. H. MORRISON,
Oil and Gas Power Division
W. R. ECKERT,
Petroleum Division
F. M. GIBSON and W. M. KEENAN,
Power Division
WINFIELD S. HUSON,
Printing Industries Division
MARION B. RICHARDSON,
Railroad Division
JAMES W. COX, JR.
Textile Division
WM. BRAID WHITE,
Wood Industries Division

Management

Measure of Accomplishment for Machine Shop

Mg-2 What measure of accomplishment can be set up for a machine shop manufacturing experimental models and machinery for the engineering organization of a manufacturing concern? The construction of experimental machines is charged to the interested organization at cost. No two jobs are alike—they vary from the drilling of a few holes to the construction of elaborate or intricate machines costing many thousands of dollars.

One method of evaluating manufacturing operations, which is being used successfully by several manufacturing companies, is the kilo man-hour method proposed by L. P. Alford and the writer in a paper[1] presented at the last annual meeting of the Society. Man-hours are used by this method, but not in the usual manner for determining the number of hours to do certain jobs. The kilo man-hour method utilizes the actual number of man-hours worked for a definite period as the common denominator, and not as the numerator, of various rates. Either physical or monetary values may be used as the numerators, and all the rates thus obtained will be comparable, since the same value, kilo man-hours, is used as the denominator in each case. It is suggested that 1000 man-hours be used rather than man-hours in order that the rates may be expressed in whole numbers.

The kilo man-hour rates can be determined for any or all of the values incident to the operation of any business such as fixed capital investment in buildings and machinery, direct and indirect costs, prime costs, wages, cost of materials, overhead charges, manufacturing costs, profits, selling price, physical volume of product, number of workers employed, horsepower utilized, frequency and severity of accidents, etc.

The rates may be determined on an annual basis for the plant as a whole, or they may be calculated weekly or monthly for any department or set of operations. Results obtained before and after important changes in manufacturing procedure may be measured and compared.

The method is simple in its application. No complicated calculations are required. It is necessary to record accurately the actual number of man-hours worked, whether on piecework or straight time. The actual number of overtime hours worked should be included. The total man-hour figure should include all direct and indirect factory labor, that is, the total number of man-hours worked by all employees engaged in plant operation and maintenance. (J. E. Hannum, Editor, *The Engineering Index Service*, New York, N. Y.)

[1] "A Basis for Evaluating Manufacturing Operation," by L. P. Alford and J. E. Hannum, MECHANICAL ENGINEERING, vol. 51, no. 3, March, 1929, p. 181.

Fuels

Coal for Forced-Draft and Preheat Conditions

F-12 What coal specifications are recommended for forced-draft conditions such as are encountered in Taylor stokers operating on 400-deg. preheated air?

There are a number of factors involved in the selection of the proper type of fuel to be used in any given installation, and it is impossible to say just what kind of coal can be burned most successfully unless more information is given.

The principal factor in the selection of the proper fuel lies in the type of furnace in which this fuel is to be burned. Is the furnace constructed with ordinary brick walls, side, front, and rear? Does it have a rear water-cooled wall or both side and rear water walls? What is the furnace volume and the rate of B.t.u. liberation at which the boiler is to be operated? These are the determining factors in the selection of the proper fuel.

If the furnace contains a completely water-cooled rear wall and partially water-cooled side walls, and if the normal B.t.u. liberation rate is around 25,000 to 35,000 B.t.u. per cu. ft. per hr., any type of bituminous coal may be burned satisfactorily with 400-deg. air from the highest grades of Eastern coals to the lowest grades of Western coals. (P. N. Oberholtzer, Engineer, American Engineering Company, Philadelphia, Pa.)

Questions to Which Answers Are Solicited

Heat Transfer in Cooking Equipment

M-8 What is the rate of heat transfer between hot water and cooking meat in jacketed cooking equipment?

Leaky Boilers Following Use of Water Softeners

P-3 A user reports leaky seams and rivets following the use of softened feedwater. What may be the cause of this and what remedies are suggested?

Troubles With High Boiler Pressures

P-4 What troubles have so far been experienced with high boiler pressures on locomotives?

MECHANICAL ENGINEERING

A Monthly Journal Containing a Review of Progress and Attainments in Mechanical Engineering and Related Fields, The Engineering Index (of current engineering literature), together with a Summary of the Activities, Papers, and Proceedings of

The American Society of Mechanical Engineers

29 West 39th Street, New York

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Contributions of interest to the profession are solicited. Communications should be addressed to the Editor.

BY-LAW: The Society shall not be responsible for statements or opinions advanced in papers or . . . . printed in its publications (B2, Par. 3).

The Fiftieth Annual Meeting

THE COMING Annual Meeting is "Number Fifty" in the series of notable gatherings which, since the founding of the Society, have exerted a profound influence on mechanical-engineering development through the stimulation of the individual enthusiasm of the members of the profession by contact and interchange of experience and information.

The coming event presents a program in marked contrast to the simple early meetings of the Society which were given over to a few technical subjects of tremendous import then, but, like the steam engine, of less value now. On the other hand, the discussions of general matters such as the development of the profession contain many principles that may be equally applicable now.

For the first time in the history of the Society the program starts early on Monday morning and extends without break through Friday afternoon. It offers a wide diversity of topics for discussion, which, after comparison with the first Annual Meeting in 1880, is proof of the way in which mechanical engineering has grown in range and importance. This great technical conference in New York from December 2 through 6, fitting closure to fifty years of important technical achievement, clears the way for the Fiftieth Anniversary Celebration in April, which will be focused on the social and economic effects of the technological advance of the past fifty years.

Cooperation Will Extend Standardization

A MANUFACTURER has called attention to a phase of standardization which has not been sufficiently emphasized. In the work, in which the Society has assisted, of standardization of cast-iron and steel flanged fittings, both manufacturer and consumer have benefited by simplification or the elimination of sizes and styles. In spite of this good work, however, manufacturers find that customers are still calling for special sizes, and inquiry usually shows that the special pipe flanges are necessary in order to make a connection with some piece of equipment, such as a boiler nozzle, a condenser, or a pump, whose flange has been made without regard to the established American standards. The obvious necessity exists of extending this program of simplification and standardization to manufacturers who make equipment to which pipe connections must be made by means of flanges. For as long as designers of such equipment feel themselves not governed by these standards or are ignorant of them, makers of pipe fittings and companion flanges will be faced with the necessity of supplying non-standard flanges and the efforts expended in the interests of economy will fail of their full accomplishment.

Around the World by Air

THE trip of the Zeppelin around the world by air in four jumps is undoubtedly one of the finest performances of modern times. There is an outstanding significance in the fact that the ship crossed both oceans and three continents under a substantial load, through all kinds of weather, without apparent trouble, and in a remarkably short time. Whether or not this augurs immediate development of commercial communication by lighter-than-air craft remains to be seen, but the big step toward the establishment of such communication unquestionably has been made. It is only fair to mention in this connection the splendid work of Doctor Eckener, both as the designer and pilot of the *Graf Zeppelin*. It is also well in the light of this performance to call attention to the foresight of the United States Navy in ordering a year ago the construction of two vessels even bigger than the *Graf Zeppelin*. The American vessels, by the way, will be filled not with hydrogen but with helium, and it will be interesting to see how, if at all, the performance of airships is affected by the lifting gas used.

The "Bremen" and the "Mauretania"

IN THE editorial on the wonderful performance of the German transatlantic liner *Bremen* in the September issue of MECHANICAL ENGINEERING, it was pointed out that the question of speed of the large transatlantic liners is not so much a matter of engineering as of business policy.

According to a statement by Dr. Bauer, the designer, the propelling machinery of the *Bremen*, as reported in *The Engineer*, is of the order of 130,000 s.hp. (whether for the turbines alone or including the auxiliary generator plant is not stated). The boiler plant consists of twenty water-tube boilers, eleven of which are double ended and the rest single ended, giving a tube heating surface of about 161,460 sq. ft. Steam is generated at a working pressure of 327 lb. per sq. in., with a total temperature of 700 deg. fahr. The fuel consumption of the *Bremen* has been officially stated as 0.685 lb. of oil per shaft horsepower-hour for all purposes, which means an hourly consumption of nearly 90,000 lb. This figure is said to include the main and auxiliary propelling-machinery load besides the loads for lighting, heating, and all the hotel services. There is no need to add that 90,000 lb. of fuel represents a figure that, to use a slang expression, "runs into real money."

An interesting light on the relation between speed and profits is thrown by the Cunard Company's policy as shown by the *Mauretania*. Last year extensive refitting was done on this vessel, and after the *Bremen* made its record-breaking passage, the *Mauretania* showed that it had a considerable reserve of speed. It crossed the Atlantic in 4 days and 17 hours, not beating the

Bremen record, but considerably exceeding its own previous record. The significance, however, is that the *Mauretania* did not show its full speed until it was forced to do so by the *Bremen*. This is only natural because this additional speed, without probably bringing any important new business, will cost the liner considerable additional money. Just what is the advantage of the higher speed to the North German Lloyd is not evident, except that it has resulted in tremendous publicity which may be worth the cost in additional fuel and other expenses.

Broadening Engineering Education

ONE of the tendencies in modern engineering education, brought out by Dean Kimball and others at the S.P.E.E. summer school for mechanical engineering teachers held early in the summer at Purdue University, is the broadening of the course of instruction to include subjects which would have appeared alien to the true purpose of such education a generation ago. Already the economic and social sciences have gained a foothold in many schools to the exclusion, in some cases, of highly specialized courses of a strictly technical and engineering nature. There is strong evidence that soon there may be added such valuable and cultural subjects as history. This is in line with the modern conception of the engineer as a leader whose vision must transcend the understanding of technicalities and whose position is that of a leader in society and in industry. For such positions only the most capable men will find themselves fitted. In the past, natural ability, augmented by a general education and a training in the affairs of business, have carried men to these positions of responsibility and power. In the future, as civilization comes to depend more and more upon mechanization, the general education must be replaced by a liberalized engineering education.

International Conferences

PERIODICALLY in the past, and now more frequently, several organizations of international scope have held meetings and conferences in as many places in the world to discuss and adopt resolutions and to draft specifications of various kinds. Within the past year the International Commission on Illumination met in Saranac, New York, the Fuel Conference of the World Power Conference convened in London, a Sectional Meeting of the World Power Conference met in Barcelona, the International Conference on Large Electric High-Voltage Networks and the Executive Committee of the International Commission on Large Dams met in Paris, and several advisory committees of the International Electrotechnical Commission held meetings in London.

The reports originating from all of these meetings and conferences indicate that in the main the discussions result in resolutions, actions, or agreements which receive the unanimous approval of the delegates sent by the engineering and industrial organizations of the various countries. In other words, representatives of many nationalities gather together under auspicious circumstances and reach international agreements in their several fields.

In July, for instance, I.E.C. Advisory Committee No. 5 on Steam Turbines, made up of representatives of ten countries, met for a full week in London in the Council Room of the Institution of Civil Engineers. This was the fourth annual meeting held by this committee: New York in 1926, Bellagio, Italy, in 1927, and The Hague in 1928. At the close of the London meeting, as a report printed on another page of this issue indicates, this committee had practically completed a document in two parts covering Part I, "Specifications," and Part II, "Rules for Acceptance Tests," of the I.E.C. Document on Steam Turbines.

Too much importance cannot be given to the value of these international gatherings and the bearing which the papers produced have on the engineering and the industrial practice of the participating countries. There can be no question but that engineers contribute directly through them an international atmosphere of good will and friendliness as well as arriving at conclusions in technical matters. On the commercial or practical side the decisions of the International Electrotechnical Commission provide for the purposes of international commerce an equitable basis for the comparison of estimates. In the case of the work on hydraulic and steam turbines, agreements have been reached concerning the content of codes covering acceptance tests of these prime movers. By accepting the I.E.C. recommendations for international purposes, the national committees are under no obligation to modify their national standards. On the other hand, with the general consent of the industry concerned, the recommendations of the I.E.C. are given publicity and permeate gradually the national standards.

The Schneider Cup Races

IN THE early days of the automobile industry the public and the leading men on the inside had widely varying opinions concerning the participation of the companies in automobile racing. A somewhat similar attitude exists with respect to aeroplane racing. In the recent Schneider Cup races speeds close to 330 m.p.h. were developed, while in a semi-official test following the race the winning British plane made a speed better than 360 m.p.h. Is there any advantage outside of publicity to be derived from such performances?

To an engineer it is unquestionable that there are such advantages. Planes like the Schneider Cup racers, in the first place, represent, embodied in wood and metal, the true reports of progress in airplane design. The fact that the speed of the cup winners rose from 105 m.p.h. in 1920 to 329 in 1929 illustrates better than anything else the enormous progress in aeronautics during these nine years. The further fact that after the end of the race the winning plane was in condition to undergo a further grueling test at 365 m.p.h. on a straightaway shows that a truly remarkable advance in the materials and methods of construction has been accomplished.

What is more, as in automobile engineering, the racing plane of today is the stock plane of tomorrow. From 80 to 100 m.p.h. at Indianapolis 10 years ago we have come to the recent Texas law permitting a speed of 70 m.p.h. on state roads in the sparsely populated counties. In 1920 the Schneider Cup racers developed the "terrific" speed of 105 m.p.h. Today a number of commercial planes are available with a cruising speed of from 130 to 150 m.p.h.; and the fact that 360 miles has been successfully accomplished under the somewhat unusual conditions of racing bears the promise that not many years will pass before such speeds will be taken as calmly as we take 50 m.p.h. by automobile or 150 m.p.h. in present commercial planes.

Another bogey, by the way, has been laid to rest, and that is the alleged inability of the human body to stand such tremendous speeds. From all indications neither the British nor the Italian fliers suffered any excessive discomforts during the race and all managed to take their turns at the pylons without losing consciousness. When Stephenson applied for his first railroad charter, members of the British parliament were fearful that a speed of 10 m.p.h. would result in suffocation. The human constitution is apparently capable of standing tremendously greater speeds, and the only question that remains is whether or not there is any limit to the speed that one can stand. Orlebar's speed of flight is already of the order of close to one-half the speed of sound. The end is not yet in sight by any means.

Steam-Turbine and Steam-Table Conferences

Reports of Two International Meetings in London Attended by American Engineers

DURING the early part of the summer, two important international conferences, one on steam turbines and the other on the steam tables, in which American engineers and scientists took part, were held in London. At the meeting of the International Electrotechnical Commissions' Advisory Committee No. 5 on Steam Turbines, the delegates practically completed the proposed I. E. C. Document on Steam Turbines, Part I of which is devoted to "Specifications," and Part II to "Rules for Acceptance Tests." The experts who discussed the possibility of establishing an international steam table were able to evolve a program of future procedure by which there will be established, and periodically revised, certain points and tolerances in their values, with the understanding that any current table whose values fall within the tolerances becomes an international table. Brief accounts of both meetings follow.

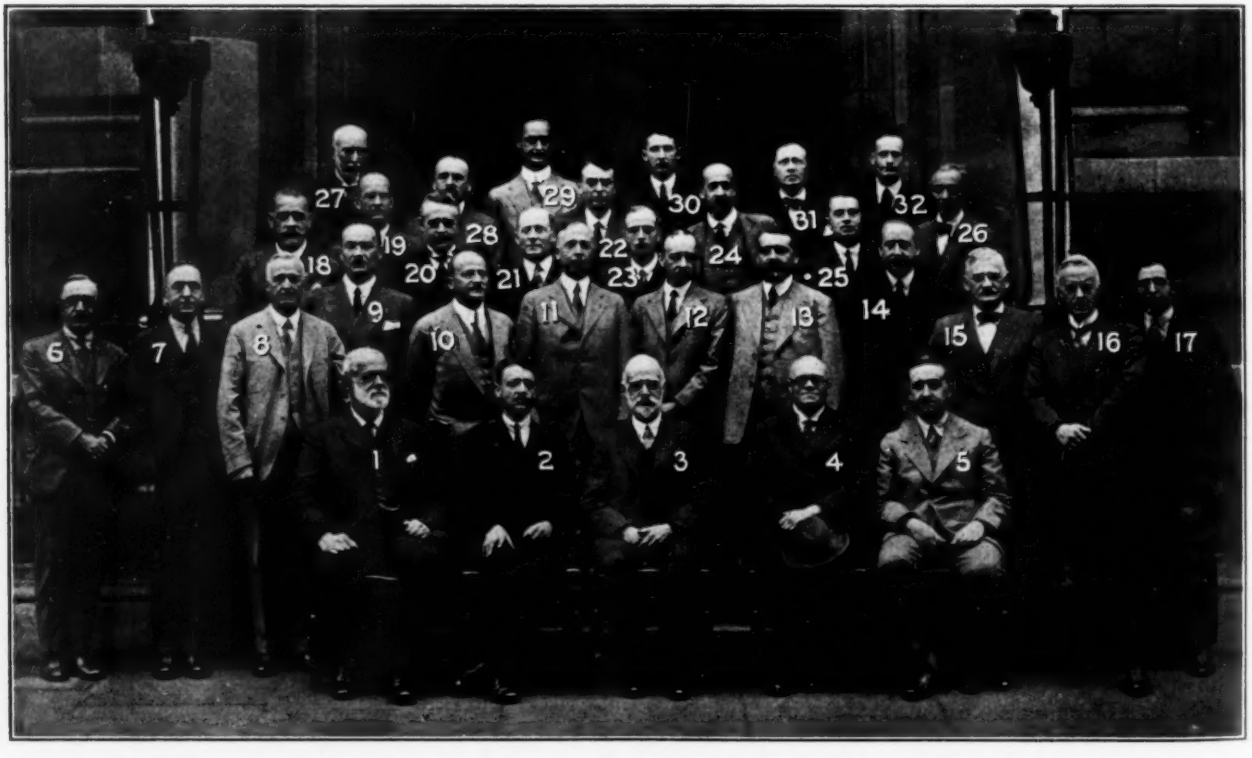
I.E.C. Advisory Committee No. 5 on Steam Turbines

Substantial progress toward the completion of the I.E.C. Document on Steam Turbines was made at the meeting of I.E.C. Advisory Committee No. 5, held in London, July 1 to 6. This was the fourth meeting at which this subject was discussed, the previous meetings having been held at New York (1926); Bellagio, Italy (1927); and The Hague, Holland (1928).

Following the New York meeting, the United States National Committee of the International Electrotechnical Commission was designated as the Secretariat of this advisory committee and the similar one on hydraulic turbines. Accordingly, during the past three years it has been charged with the responsibility of preparing and editing most of the proposals which have been studied at the several meetings. The bases of these proposals are the specifications or codes which previously have been formulated by the interested engineering and industrial groups of the several member countries.

In Great Britain, the Institution of Civil Engineers has developed the "Report on Tabulating the Results of Heat Engine Trials;" in Germany, the Verein Deutscher Ingenieure and the German National Committee of the I.E.C. have developed rules for acceptance tests on steam turbines; and in the United States, The American Society of Mechanical Engineers has formulated a "Power Test Code for Steam Turbines." The trade and engineering practices of the seven additional countries forming I.E.C. Advisory Committee No. 5 have been duly considered during the progress of the work. These countries are, respectively, Canada, Czechoslovakia, France, Italy, Norway, Sweden, and Switzerland.

The representation at the London meeting was practically the same as that of The Hague meeting. It was as follows: Canada, not represented; Czechoslovakia, not represented; France, G. Darrieus and L. Cauchois; Germany, E. Josse, Dr. E. A. Kraft, and P. Reuter; Great Britain, W. H. Patchell, W. S. Burge, J. P. Chittenden, F. W. Gardner, H. L. Guy, B. Pochobradsky, I. V. Robinson, R. Roles, F. Samuelson, Dr. G. Stoney,



Delegates to the London Meeting of the I.E.C. Advisory Committee No. 5 on Steam Turbines and Their Secretarial Assistants

(1) W. H. Patchell, (2) G. Darrieus, (3) W. F. Durand, (4) E. Josse, (5) A. Anastasi, (6) C. Le Maistre, (7) F. Hodgkinson, (8) I. E. Moultrop, (9) E. A. Kraft, (10) A. Meyer, (11) C. B. Le Page, (12) M. G. S. Swallow, (13) L. Cauchois, (14) J. P. Chittenden, (15) F. Samuelson, (16) I. V. Robinson, (17) L. Ruppert, (18) P. Reuter, (19) O. Rast, (20) H. L. Guy, (21) R. Roles, (22) B. Pochobradsky, (23) F. W. Gardner, (24) W. S. Burge, (25) M. T. Lindhagen, (26) P. Good, (27) Dr. G. Stoney, (28) E. Forgeur, (29) J. de Freudenreich, (30) E. Pyk, (31) A. Dalla Verde, (32) J. F. Stanley

M. G. S. Swallow and C. Le Maistre, general secretary of the I.E.C.; Italy, A. Anastasi and A. Dalla Verde; Sweden, M. T. Lindhagen and E. Pyk; Switzerland, A. Meyer, J. de Freudenreich, and O. Rast; United States, Dr. W. F. Durand, F. Hodgkinson, I. E. Moultrop, and C. B. Le Page, assistant director of the Secretariat; Belgium, Baron E. Forgeur; and Holland, Dr. C. Fieldmann, president of the International Electrotechnical Commission.

The meeting was opened by Mr. Charles P. Sparks, chairman of the British National Committee of the I.E.C. At the close of his introductory remarks he suggested that Dr. William F. Durand, chairman of the United States delegation, be elected to serve as chairman of the London meeting. This suggestion met with the approval of the delegates and the chairmanship was accepted by Dr. Durand.

The first paper to be considered was Part I of the complete document known as "Specifications." These specifications are based on a publication of the British National Committee and cover definitions and information to be supplied with inquiry or order as well as the recommended standard ratings and steam pressures relevant to an international document on steam turbines. In its present revised form this part is practically in shape for submission to the International Electrotechnical Commission when it meets in Stockholm in June, 1930. The members of the committee are still considering the form and content of an Appendix to Part I which will carry certain recommendations concerning standard ratings of steam turbines and standard steam pressures.

By far the greater part of the meeting was given over to a study of the "Rules for Acceptance Tests," Part II of the new I.E.C. document. By agreement at this and the previous meeting this part is to be made up of the following five sections: (1) Object and Scope, (2) Enumeration and Description of Terms, (3) Guiding Principles, (4) Computation of Results, and (5) Data and Results. This arrangement of material is similar to that adopted by the A.S.M.E. Committee on Power Test Codes in 1919. Through the activities of sub-committees the content of these sections is now practically agreed upon. During the coming year the Secretariat and a special editing committee will complete the revision in time for final consideration by the Advisory Committee prior to and during the Stockholm meeting.

In addition to Parts I and II, the I.E.C. Document on Steam Turbines will have an appendix dealing with instruments and methods of measurement. Considerable progress has been made in the development of the paragraphs of this appendix, but its completion and inclusion in the I.E.C. document will probably require a year or two longer.

The British committee has a reputation for hospitality, and the social program for this meeting was equal to their best. It consisted of a complimentary luncheon at the Royal Automobile Club, a banquet at the Hyde Park Hotel, and a day's trip to Oxford. During meeting days the ladies of the delegates were entertained by trips to many points of interest, luncheons, and teas. The visiting delegates entertained the British delegates and their ladies at a luncheon given at the R.A.C. on the Thursday of the meeting week.

It will be recalled that the World Power Conference held in London in 1924 requested the I.E.C. to take up actively the development of international agreements relative to test codes or specifications for prime movers. Prior to that time committees in Great Britain, Switzerland, Germany, and the United States had developed national codes for water turbines, steam turbines, internal-combustion engines, etc. In 1925 the U. S. National Committee of the I.E.C. invited The American Society of Mechanical Engineers to accept membership and later recognized the A.S.M.E. Committee on Power Test Codes as the authoritative group in the United States on the testing of prime movers. This invitation was accepted and the A.S.M.E. through its five representatives on the U. S. National Committee has since taken an active part in the conferences on this subject. Some of them attended the meetings of the I.E.C. Advisory Committees held in New York, Bellagio, The Hague, and London.

INTERNATIONAL CONFERENCE ON STEAM TABLE[1]

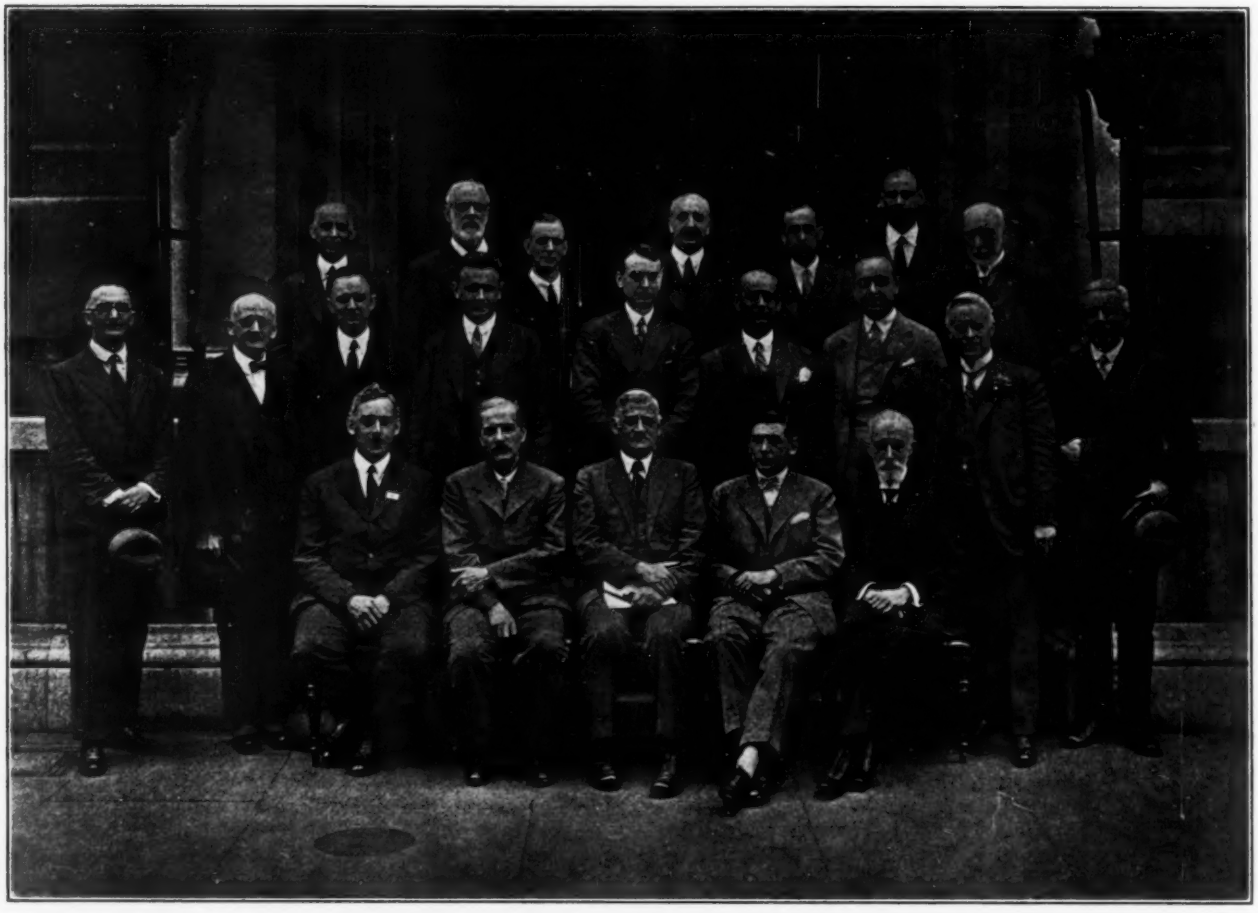
The conference of experts in the steam-table field, called together by the Engineering Research Association of Great Britain, met in the Council Chamber of the Institution of Mechanical Engineers, London, on Monday, July 8, 1929. Dr. Samuel Adamson, President of the I.Mech.E., opened the conference and Sir Richard Glazebrook was selected as chairman. There were present as delegates the Czechoslovakians, Dr. J. Havliček and Prof. Dr. L. Miskovsky; the Germans, Geh. Prof. Dr. O. Knoblauch, Dr. W. Koch and Dr. H. Hausen of Munich, Geh. Prof. Dr. R. Mollier of Dresden, and Prof. Dr. M. Jakob of the Reichsanstalt in Charlottenburg; the Britishers, Prof. H. L. Callendar, F.R.S., and his son, of the Imperial College of Science in London, Mr. F. Samuelson, of the British Thomson-Houston Company, Dr. G. G. Stoney, of C. A. Parsons and Company, Mr. H. L. Guy, Chief Engineer, Mech. Eng. Dept. Metropolitan-Vickers Electrical Co., Mr. I. V. Robinson of B.E.A.M.A., and Mr. E. B. Wedmore of the E.R.A.; and the Americans, Mr. Geo. A. Orrok of New York, Pres. Harvey N. Davis and Prof. J. H. Keenan of Stevens Institute of Technology, Hoboken, and Dr. Dickinson and Mr. N. S. Osborne of the United States Bureau of Standards. A number of other gentlemen, notably Dr. W. H. Patchell of London, past-president of the Institution of Mechanical Engineers, Mr. Francis Hodgkinson, of the Westinghouse Electrical and Manufacturing Company, and Mr. C. B. Le Page, of the A.S.M.E. Staff, were welcome guests at the sessions. Mr. D. V. Onslow of E.R.A. acted most efficiently as secretary of the conference and Mr. B. Pochobradsky, a well-known British turbine designer, and Prof. S. J. Davies, of London, served with notable skill as interpreters. Both German and English were used freely throughout the conference. It was, however, noticeable that, as the conference progressed, the continental delegates made increasingly successful efforts to express themselves directly in English, so as to save the time required for translation, a courtesy which most of the British and American delegates were unable to reciprocate.

The spirit of the conference was excellent throughout, and the newly formed acquaintances of the first day rapidly ripened into warm personal friendships before the week was over, a result which is by no means the least of the happy results of the conference. This outcome might well have occurred in any case, but its progress was much facilitated by the rare skill and tact of the presiding officer, Sir Richard, during the crucial early days, and by the somewhat different but equally admirable handling of the meetings by Mr. Robinson on those days when Sir Richard was obliged to devote himself to other duties. The interpreters also contributed largely to the success of the conference, not only on its technical but also on its personal side.

The first two and a half days were largely devoted to general discussion. Each delegate described at length and in detail the experimental apparatus which he himself had used, answering numerous questions as to his technique, and parrying or accepting numerous keen, even if friendly, criticisms of his set-up and procedure. The remaining two and a half days, and large portions of the intervening nights, were devoted to perfecting the details of the program which was then evolved.

Briefly, this program consists of establishing, and of periodically

[1] This account of the Conference was prepared by Dr. Harvey N. Davis, of the American delegation.



Delegates to the International Steam-Table Conference
Top row: H. C. Dickinson, W. H. Patchell, S. J. Davies, D. V. Onslow, N. S. Osborne, J. H. Keenan, G. Stoney
Middle row: E. B. Wedmore, Geo. A. Orrok, H. Hausen, L. Miskovský, B. Pochobradsky, M. Jakob, W. Koch, I. V. Robinson, R. Mollier
Bottom row: Harvey N. Davis, H. L. Callendar, F. Samuelson, J. Havlíček, O. Knoblauch

revising, a network of fixed or test points in the saturated and superheated regions, at each of which there is to be, not only an agreed-upon value of volume and of total heat, but also an agreed-upon tolerance or measure of uncertainty in each of these values. The result will be not a usable steam table, but a highly condensed extract form, or summary, of such a table. If at each of these "test points," any of the present tables or formulations lies closer than the selected tolerance to the selected value, then that table is, at least for the present, an international table. If two such international tables disagree, there is, as yet, no internationally agreed-upon way of deciding which is more nearly right, and, in a case in dispute, an average of the two is as fair a compromise as any other. Furthermore, any existing table can be transformed into an international table by using with the existing table a graphical chart for volumes, another for total heats, etc., no one of which needs to be larger than a sheet of typewriter paper to give entirely adequate accuracy.

The chief value of this program lies in the expectation that the international fixed-point tabulation will be periodically and frequently revised. It was agreed that another conference shall be called in 1930, at which an attempt will be made to meet still more accurate values and narrower tolerances. And there will be a third, fourth, and other conferences following at appropriate intervals. In this way the various steam tables in daily use in different parts of the world will be brought into closer and closer agreement as fast as the minds of the various experts behind them can be brought into real and, therefore, dependable agreement as to the facts.

Such a program cannot stifle progress, for each improved formulation or table that individual initiative may produce will be welcomed as a closer approximation to the ultimate goal of this work, the "international table." Furthermore, the publication of the international fixed-point values with their tolerances, which will be released in due season by the permanent secretary of the conference, will inevitably concentrate the attention of the ablest experimenters of the world on precisely those regions where the tolerances, and therefore, the international disagreements, are largest and least satisfactory, and this in turn will make each revision more effective.

One other result of the conference was regarded by many of the delegates as of great importance. It adopted for its own use, and recommended to the various national testing laboratories and to the world in general, the definition—

One international kilowatt-hour equals 860 international kilocalories.

The international calory which is defined by this equation will no longer change with each increase in the precision of our knowledge of the specific heat of water. It is a fundamental unit of heat which is, and will remain, known with the same precision that characterizes the international electrical units. Its universal adoption will greatly simplify the tasks of all who wish either to work, or to think, with precision in the heat field.

Book Reviews and Library Notes

THE Library is a cooperative activity of the A.S.C.E., the A.I.M.E., the A.S.M.E., and the A.I.E.E. It is administered by the United Engineering Society as a public reference library of engineering and the allied sciences. It contains 150,000 volumes and pamphlets and receives currently most of the important periodicals in its field. It is housed in the Engineering Societies Building, 29 West 39th St., New York, N. Y. In order to place its resources at the disposal of those unable to visit it in person, the Library is prepared to furnish lists of references on engineering subjects, copies of translations of articles, and similar assistance. Charges sufficient to cover the cost of this work are made.

The Library maintains a collection of modern technical books which may be rented by members residing in North America. A rental of five cents a day, plus transportation, is charged. In asking for information, letters should be made as definite as possible, so that the investigator may understand clearly what is desired.

The Stodola 70th Anniversary Commemorative Volume

REVIEWED BY GEO. A. ORROK[1]

FESTSCHRIFT. PROF. DR. A. STODOLA, ZUM 70. GEBURTSTAG. Orell Füssli Verlag, Zurich and Leipzig, 1929. Paper, 6½ × 9½ in., 602 pp., illus., tables, $5.

FOLLOWING the example set so long ago by the students and friends of the late Prof. Dr. Riedler, a group of prominent European engineers, most of them students or associates of Dr. Stodola, have celebrated the attainment of his seventieth birthday by publishing a volume of their original technical papers covering a wide engineering field to correspond to the many-sidedness of Dr. Stodola's accomplishments.

While Parsons, de Laval, and Rateau were the pioneers in the practical development of the steam turbine, Aurel Stodola, studied and taught its theory to many students during the past forty years and his work in this line is unique in its treatment of the subject.

The foreword is by Rohn, the president of the Swiss Board of College Education and this is followed by a carefully considered biography of Aurel Stodola by W. G. Noack.

The 63 technical papers by students and associates cover 600 pages of most interesting reading.

Among the names of the contributors one finds: A. Einstein, Föppl, Honegger, Jakob, Kraft, Havliček, Lorenz, Mollier, Nusselt, Prandtl, Schüle, and others, experts in different fields. The articles are rendered extremely interesting by their condensed form which necessitates an unusually high standard of mathematical treatment. It is by no means easy reading for novices, but gives the working engineer new ideas on many subjects couched in generalized mathematical expressions.

The question of turbine blading has been dealt with by J. Acheret, Colombi, Darrieus, Dubois, Flatt, Lösel, Seippel. The thermodynamics has been covered by Jacob, Havliček, Miskovsky, Mollier, Nusselt, Schüle, and Zerkowitz. Considerable work is shown on vibration and on the strength of turbine parts. Especially interesting is Honnegger's paper on thermal stresses. The experimental work on Diesel engines, locomotives, turbines, and internal-combustion turbines is also well represented. Huguenin presents a paper on air liquefaction by the Linde, Claude, and cascade processes and describes the Toulouse synthetic ammonia plant. The short article by A. Einstein on his new field theory is a beautiful abstraction even for the uninitiated and its outstanding feature is the way this abstraction shows the difference between the scientist's and the engineer's mental tools and the materials on which their efforts are exerted.

This book should be included in the library of all who are interested in the design, construction, and operation of turbines as a sequel and completion of Stodola's monumental work on the steam turbine.

The book sells for $5, the proceeds going to Dr. Stodola as a birthday present. The papers have been published in the languages in which they were written.

[1] Consulting Engineer, New York, N. Y. Mem. A.S.M.E.

Books Received in the Library

SIMPLE AERODYNAMICS AND THE AIRPLANE. By Charles N. Monteith. Third edition revised by C. C. Carter. Ronald Press Co., New York, 1929. Cloth, 6 × 9 in., 418 pp., illus., diagrams, $4.50.

A revised, enlarged edition of a popular textbook written to meet the requirements of the course in aerodynamics given at the U. S. Military Academy. The new material comprises chapters on material, construction, equipment, navigation, and military airplanes.

The text gives a sound but not highly technical presentation of fundamental principles, with sufficient descriptive matter to familiarize the student with practical appliances. It is suited for home study, and for use as an introductory textbook in courses in aeronautical engineering.

STRENGTH OF MATERIALS. By Arthur Morley. Seventh edition. Longmans, Green & Co., New York, 1928. Cloth, 6 × 9 in., 569 pp., illus., diagrams, tables, $4.20.

Covers the ground of the usual college courses in the subject, paying attention to several subjects, such as the strength of rotating disks and cylinders, and unstayed flat plates, the bending of curved bars and vibratory stresses, which are sometimes given scanty treatment. The changes from the sixth edition consist of added articles on the circular stress diagram and a rewritten statement about fatigue of metals.

THEORETICAL MECHANICS. By Joseph S. Ames and Francis D. Murnaghan. Ginn & Co., Boston and New York, 1929. (Engineering Series.) Cloth, 6 × 9 in., 462 pp., $5.

The purpose of this work is to provide students of physics, mathematics, and chemistry with a text and reference book which will correspond with the new view of theoretical mechanics which has resulted from recent advances in mathematical physics. It includes a systematic treatment of vector analysis, gyroscopic theory, wave motion, etc. The volume furnishes a foundation for advanced study of statistical mechanics, quantum dynamics, atomic theory, etc., and is adapted for class or private study.

THEORY OF HEAT. By Thomas Preston. Fourth edition. Macmillan Co., London and New York, 1929. Cloth, 6 × 9 in., 836 pp., illus., diagrams, tables, $8.50.

This comprehensive survey, from a historical point of view, of

the development of the theory of heat, has been a favorite work since its appearance in 1894. The clear, connected account, illustrated by critical discussions of typical experiments, gives the reader a clear view of the subject, not limited by adherence to any arbitrary standards of curriculum or mathematical attainments.

This revision is chiefly in the experimental determinations of thermal data. The book has been brought up to date by careful additions and omissions.

THEORY OF THE GYROSCOPIC COMPASS AND ITS DEVIATIONS. By A. L. Rawlings. Macmillan Co., London and New York, 1929. Cloth, 6 × 9 in., 191 pp., diagrams, tables, $3.50.

Dr. Rawlings, who has been intimately connected with the development of the gyro-compass, here attempts to explain its theory in a way that can be understood by those who manufacture and use it. The forms in commercial use today are described quite fully, and considerable space is devoted to the claims of rival inventors.

THOMAS' REGISTER OF AMERICAN MANUFACTURERS AND FIRST HANDS IN ALL LINES. 1928–29. Thomas Publishing Co., New York, 1929. Cloth, 9 × 12 in., 4500 pp., $15.

The three main divisions of this register, the classified, alphabetical, and trade names, answer satisfactorily almost any inquiry relating to sources of articles made or sold in the United States. Useful minor lists of banks, commercial organizations, and trade papers are included. Purchase and sales departments and business libraries will find it most useful.

LE TRAVAIL DES MÉTAUX AUX MACHINES-OUTILS. By M.-J. Androuin. J.-B. Baillière and Son, Paris, 1929. Paper, 6 × 9 in., 499 pp., illus., 80 fr.

A detailed study of the manner in which tools act on the material, both with respect to the quality and rapidity of action. In the first part of the book are treated general problems, such as the action of tools on metal, tool steels and their treatment, economical working conditions, and tool speeds. The second part is devoted to the peculiarities of the various processes of working.

ÜBER DEN STRÖMUNGSVERLUST IN GEKRÜMMTEN KÄNALEN. (Forschungsarbeiten auf dem Gebiete des Ingenieurwesens. Heft 320.) By H. Nippert. V.D.I. Verlag, Berlin, 1929. Paper, 8 × 12 in., 67 pp., illus., diagrams, 9 r.m.

With the support of various German engineering and physical societies and firms, the author has made an extensive investigation of the flow of water in curved pipes and channels. He reviews previous investigations of stream flow and losses in bends, describes the various factors that determine them, and investigates very fully the effect of certain of these factors by careful experiments. The results are given in graphic charts and in photographs of flow in open channels.

Synopses of A.S.M.E. Transactions Papers

THE papers abstracted on this and following pages appear in Fuels and Steam Power, Iron and Steel, and Oil and Gas Power sections of A.S.M.E. Transactions. These sections have been sent to all who registered in the similarly named Divisions. Other sections are in the course of preparation and will be announced, when completed, in later issues of "Mechanical Engineering."

FUELS AND STEAM POWER PAPERS

PROGRESS IN FUEL UTILIZATION IN 1928. [Paper No. FSP-51-21]

This report, contributed by the Fuels Division of the A.S.M.E., briefly reviews the progress of the preceding twelve months in the production, preparation, and storage of fuels; stokers; the use of pulverized fuel; high steam pressures; locomotive practice; gas manufacture; low-temperature carbonization; smoke abatement; and research in fuel utilization.

JOINT RESEARCH COMMITTEE ON BOILER-FEEDWATER STUDIES. [Paper No. FSP-51-22]

Through this committee, six national technical organizations are cooperating actively in a study of the various processes employed in the purification of feedwater in steam power plants and on railroads. This research is being carried on to determine the fundamental principles underlying certain phenomena which take place in steam boilers. This paper comprises reports of three of the nine sub-committees, which deal respectively with: zeolite softeners, internal treatment, priming and foaming; municipal water supplies and the effect of trade wastes in relation to the use of water in power-plant practice (including a comprehensive bibliography); and a tentative method for the determination of dissolved oxygen in boiler feedwater.

ORIFICE-STEAM-METER COEFFICIENTS. By Robert W. Angus. [Paper No. FSP-51-23]

Data to show variation of orifice coefficients with different velocities, with different positions of the pressure holes, and with different area ratios are presented by the author. The information given was obtained from tests, and graphs are plotted to show results. The paper points out the great need for an exhaustive research of steam flow under varying conditions, using an orifice meter operating under relatively low differential heads.

THE PEAK-LOAD PROBLEMS IN STEAM POWER STATIONS. By A. G. Christie. [Paper No. FSP-51-24]

This paper deals with the problem of the annual peak load in steam power plants. The use of the load-duration curve for the purpose of studying annual peak loads is analyzed and the conclusions are drawn that (1) plant intended for annual-peak-load service should only be installed at the lowest possible first cost, and that (2) economy of peak-load equipment can be sacrificed to secure low initial cost.

Various schemes that have been proposed to provide equipment for carrying the annual peak loads are analyzed. The three plans that appear most promising are those involving the use of steam accumulators, of peak-load units, and of present plant after new base-load equipment has been added.

In order to indicate the possible annual savings through the application of these three methods, the author assumes an electric system with a maximum annual peak load of 200,000 kw., together with certain data for annual load factors of 65, 45, and 25 per cent on this system. With certain assumed plant costs, fuel costs, and operating performances, an analysis is made of the annual operating costs of the various methods, and the possible annual savings through the use of steam-accumulator plant or peak-load units are shown in the form of a series of curves. These savings in some cases may be of a large order.

CONDITION CURVES AND REHEAT FACTORS FOR STEAM TURBINES. By Clarence C. Franck. [Paper No. FSP-51-25]

This paper offers a theory for "condition curves and reheat factors" developed by a study of the basic thermodynamic principles involved. A method is developed which makes possible the construction of "condition curves" for any turbine, when certain operating or guarantee characteristics are known. The question of "condition curves" immediately presents the closely related "reheat factor," and the

theory developed for the "condition curve" has been applied to determine values for "reheat factors."

POWER SUPPLY FOR NEW ENGLAND INDUSTRY. By F. M. Gunby. [Paper No. FSP-51-26]

In this paper the author gives data to show how much power New England is using, and the rate of increase, including power generated by the industries and by central stations. The growth and sources of power in the industries are analyzed, and comparative figures are given for the cost of power in various sections of the country.

The total amount of power used by the industries is increasing. In general, plants served by long transmission lines are subjected to more frequent interruptions than those with good installations of their own. On the other hand, there is less likelihood of a long shutdown, due to accident, when served by a modern, well-managed utility.

BALANCING HEAT AND POWER IN INDUSTRIAL PLANTS. By R. V. Kleinschmidt. [Paper No. FSP-51-27]

The purpose of this paper is to indicate the importance of various factors in increasing the amounts of by-product power that can be generated in industrial plants using process heat. It has been shown that there are opportunities for economies in increased boiler pressures, higher superheats, and particularly by reducing the back pressure on turbines and engines to the lowest possible point. Utilization of waste heat from furnace gases offers an opportunity for additional power generation in mixed-pressure turbines or in low-pressure condensing turbines. It is shown that hot air can be most economically used by returning it to the boiler furnace and heating air for process work with exhaust steam.

Two curves are presented which give the results of a detailed analysis of the problem of water heating, one showing the advantages of two-stage water heating as compared with heating by exhaust steam only, and the other giving the best condenser vacuum for various initial and final temperatures of water in a two-stage process. Attention is called to the importance of an adequate study, both of the heat and power requirements of the process and of possible improvements or alterations of the process as a basis for the improvement of the heat-power balance.

COAL PULVERIZERS. By W. J. A. London. [Paper No. FSP-51-28]

Commercial coal pulverizers vary greatly in their performance. While there are two principles of attrition and impact on which pulverizing mills are based, there are such radical differences of design as to raise the question of correct fundamentals. Guarantees are given on performance when the engineering problems are difficult of determination with any degree of accuracy. Analysis of what actually takes place in a mill leads to a suggested design.

STEAM-GENERATING CAPACITIES OF BOILERS. By Fairfield E. Raymond. [Paper No. FSP-51-29]

In this paper the author gives reasons why the maximum steam-generating capacity of any complete boiler unit should be calculated entirely on a heat-liberation basis, except in so far as the features of design are reflected in the value used for the weight or volume of fuel consumed per hour in the furnace and in the overall efficiency. He presents formulas which represent the fundamental conditions, and gives several examples of their use.

ANALYSIS OF COSTS OF VARIABLE-LOAD AND MULTIPLE POWER SUPPLY. By Edward H. Scofield. [Paper No. FSP-51-30a]

This study is based upon the actual performance of a plant in operation and includes a classification of costs designed to facilitate the calculation of the influence made thereon by a load of variable demand. Also it attempts to simplify the consideration of load characteristics and to determine the value of constants relating to certain factors of operation. Reference is made to the application of the results to a study for determining the economics of a power supply for the local electric railway system.

OPERATION OF A COMBINED STEAM AND HYDRO SYSTEM. By James A. Colvin. [Paper No. FSP-51-30b]

This paper comprises a discussion of operating problems of the Northern States Power Company's system located in Minnesota and Wisconsin. The Wisconsin system consists of a 110-kv. loop enclosing an area of 200 sq. mi., fed by two steam plants having a total capacity of 152,000 kw., and by 64,000 kw. of hydro capacity. Three-quarters of the load is concentrated in Minneapolis and St. Paul.

REFRACTORIES SERVICE CONDITIONS IN FURNACES BURNING ANTHRACITE ON TRAVELING-GRATE STOKERS. Progress Report of the A.S.M.E. Special Research Committee on Boiler Furnace Refractories. By R. A. Sherman, Edmund Taylor, and H. S. Karch. [Paper No. FSP-51-31]

The general object of the extensive investigation described in this report was to obtain data on the service conditions which govern the life of refractories in these furnaces, and in particular to study the nature of the slag action. The conditions investigated were: Temperature, composition, and velocity of furnace gas; temperature of refractories; and amount and composition of the solids carried in the furnace gas.

The investigation disclosed no reason why, with the proper design of furnace to obviate the extremely high temperatures and high content of reducing gas, the burning of anthracite of the sizes smaller than buckwheat No. 3 should be accompanied by more difficulty with refractories than the burning of the larger steam sizes.

DESIGN AND TEST OF A VENTURI STACK. By Alexey J. Stepanoff. [Paper No. FSP-51-32]

This paper gives the results of tests carried out on a stack operating on the venturi or ejector principle, through which the gaseous products of combustion are discharged for the purpose of inducing the proper draft.

A GRAPHICAL TREATMENT OF HEAT EXCHANGE PROBLEMS. By Jos. S. Stepanov. [Paper No. FSP-51-33]

In this paper the author points out that the graphical method has been an important tool in engineering calculations and investigations. Applying this method to the investigation of certain heat-transfer problems, he finds it convenient to introduce some new relations between the variables involved in heat transfer and to give them corresponding mathematical expression, thus simplifying the graphical presentation of the heat-transfer equations. An arrangement of interconnected diagrams around the origin of a coordinate system furnishes the numerical values of the variables pertaining to the given set of heat-transfer equations and simultaneously satisfying them. Picturing the change of variables for different conditions, these diagrams can be used for calculations as well as for investigations and for analysis of experimental data.

In the paper are given and explained equations and diagrams for handling the heat-transfer problems pertaining to surface heat exchangers and direct-contact heat exchangers, using countercurrent and parallel flow of substances, and their applications in general calculations and investigations, and in the analysis of experimental data.

LOW-TEMPERATURE DISTILLATION OF LOW-GRADE FUELS, ESPECIALLY LIGNITES. By Max Toltz. [Paper No. FSP-51-34]

This paper is not intended to be a description of the various types of apparatus which are used in low-temperature distillation of low-grade fuels. On the contrary, its main purpose is to point out the advantages which inhere in these processes, and which result in greater usefulness and economies, particularly with reference to the lignite as found in the northwestern portion of the United States.

EFFECT OF ALLOYING ELEMENTS UPON THE STABILITY OF STEEL AT ELEVATED TEMPERATURES. By A. E. White and C. L. Clark. [Paper No. FSP-51-35]

By advancing a theory for the stability of the various steels at elevated temperatures, and by giving specific data on various types of alloy steels, the authors of this paper have endeavored to throw light on the behavior of metals at high temperatures. The hypothesis advanced to account for the influence of the different alloying elements on steels when at elevated temperatures is divided into two parts; one dealing with conditions below the equicohesive temperature, and the other with conditions above it.

INFLUENCE OF COAL TYPE ON RADIATION IN BOILER FURNACES. By W. J. Wohlenberg and R. L. Anthony. [Paper No. FSP-51-36]

This paper includes the results of an application of the methods and data presented in a previous A.S.M.E. paper ("The Influence of Radiation in Coal-Fired Furnaces on Boiler-Surface Requirements, and a Simplified Method for Its Calculation," by W. J. Wohlenberg and E. L. Lindseth) to pulverized coal for a number of coals of widely varying composition. After an evaluation of radiation quantities for each of these coals, further investigation was made for the purpose of ascertaining what quantitatively measurable property of coals might be most significant in differentiating one from another during

combustion with respect to the quantity of energy which is transferred as heat to the walls of a boiler furnace. It was found, of the properties investigated, that the calorific value serves as the most consistent and useful indicator of the radiation powers of a coal as burned in the pulverized form in boiler furnaces.

IRON AND STEEL PAPERS

Progress in Iron and Steel. [Paper No. IS-51-1]

This report of the A.S.M.E. Iron and Steel Division reviews the year's advances in the production of iron ore, pig, and Bessemer steel, and improvements in furnaces, rolling mills, and coke plants, special attention being given to sheet and tube mills.

Heavy-Duty Anti-Friction Bearings. By Sidney G. Koon. [Paper No. IS-51-2]

Advantages of ball or roller bearings on almost all types of operating mechanisms are stressed in this paper. There are not only the savings in power consumption, which frequently run from 25 to as much as 60 per cent, but also collateral advantages of varying description. Frequently the bearings permit operations which without them would be exceedingly difficult or expensive.

Some of the limitations to the use of the bearings are taken up, particularly those dealing with space limitations on equipment of old design. The concurrent development of heavy-duty bearings for steel-rolling-mill work along with backed-up types of rolling mills is traced at some length. Many features of operating conditions found in steel mills are discussed in their relation to the use of bearings of this type. Lubrication and care of the bearings are also given consideration.

How much load the roller bearing will carry and how long it will carry that load satisfactorily are not yet known. The whole field of roller-bearing uses on a large scale is in process of development, and ideas have not yet crystallized on many features of the work. In the present state of development they operate successfully under many varying conditions, but it is essential that they be adapted particularly to the work which they are called upon to do. The fact that wear is practically negligible permits maintenance of constant operating conditions for a much longer period than with plain bearings, and makes a strong point in favor of the anti-friction type. It seems to be generally accepted that in a great many cases, their greater initial expense is fully justified by the results to be expected from their use.

The Hot-Blast Cupola. By F. K. Vial. [Paper No. IS-51-3]

The object of this paper is to announce a new era in cupola practice. Since prehistoric times there have been but few outstanding advances in the art of melting iron in shaft furnaces. The demand for cannon in the Middle Ages brought about a high degree of development in the foundrymen's art, and the invention of the steam engine made possible the modern factory system. Aside from these two outstanding events but little has been done to improve the metallurgical or economic performance of the cupola. There is therefore an inviting field for research to develop the following:

Control of melting conditions
Control of the chemical elements of the iron
Control of the temperature of the molten iron
Relation of slag to melting conditions, oxidation, temperature of the iron, and economy in fuel
Mastery of the far-reaching effect of heat treatment
Knowledge of the effect produced by various alloys
Ability to produce steel, malleable iron or cast iron at pleasure
A decided improvement in physical properties of all grades of iron that can be melted in the cupola
A radical improvement in fuel economy.

When these improvements are established, and there is no reason why they should not be, there will be introduced a decidedly new era in the cast-iron industry that will entirely overshadow all previous developments.

OIL AND GAS POWER PAPERS

Progress in Oil- and Gas-Power Engineering. [Paper No. OGP-51-1]

This report of the A.S.M.E. Oil and Gas Power Division opens with a brief economic survey of the status of the Diesel engine and its applications, following which the application of oil engines to railway propulsion is dealt with. Competitive steam-power developments are discussed, as well as research work in combustion now under way or projected.

Bus Engine for Gas-Electric Drive. By H. B. Hewitt. [Paper No. OGP-51-2]

Motorbuses operate under very severe and exacting conditions, and designers and manufacturers are constantly endeavoring to build better and more powerful engines for driving them. The author gives details of research work done on bus engines of the Philadelphia Rapid Transit Co., as a result of which engine b.hp. was increased over 50 per cent through increase of compression and redesign of intake and exhaust manifolds.

A Simple Method of Comparing Oil-Engine Performances. By Otto Nonnenbruch. [Paper No. OGP-51-3]

In this paper the author analyzes a number of reliable tests made on Diesel engines by disinterested authorities to determine fuel consumption per brake horsepower-hour and per indicated horsepower-hour. He finds that the friction load in all cases is constant over the whole load range, and that the fuel consumption per indicated horsepower-hour at low indicated mean effective pressures is practically the same for all types of engines. This, and the regularity with which the indicated fuel consumption increases with increasing indicated mean effective pressure, make it possible to derive the indicated fuel consumption and the indicated horsepower of an engine from brake fuel-consumption tests without indicator cards. The procedure is illustrated by examples. The general rating of Diesel engines at a standard indicated fuel consumption is suggested.

NOTE: Those who have not registered in the A.S.M.E. Fuels and Steam Power, Iron and Steel, and Oil and Gas Power Divisions whose papers are abstracted on this and the previous pages, and who desire copies of any of these papers, may obtain them by using the form given below.

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AIRPLANE DESIGN

Stress Analysis. The Analysis of Aircraft Structures as Space Frameworks—Methods Based on the Forces in the Longitudinal Members. H. Wagner. Nat. Advisory Committee for Aeronautics—Tech. Memorandum, no. 522, July 1929, 35 pp., 16 figs. Methods for determining forces in airplane fuselages and wings; general principles of statically determinate space frameworks; methods of analysis based on forces in longitudinal members of space framework with straight members, of statically determinate space framework with bent chord members, and of statically indeterminate space frame work; torsion and bending stresses calculated. Translated from Zeit. fuer Flugtechnik u. Motorluftschiffahrt, Aug. 14, 1928.

AIRPLANE ENGINES

Air-Cooled. Air-Cooled Engines. A. H. R. Fedden. Times Trade and Eng. Supp. (Lond.), vol. 24, no. 576, July 20, 1929 (Aero Sec.), p. 12. Air-cooled airplane engines of present and near future are discussed; inherent advantages of air-cooled type are outlined; increased drag is disadvantage; special drag reducing cowlings developed by National Advisory Committee for Aeronautics; preference shown for air-cooled type by air-transport operators and private owners; reliability of air-cooled type in war.

The Development of Fixed Radial Air-Cooled Engines, G. J. Mead. Soc. Automotive Engrs. Jl., vol. 25, no. 2, Aug. 1929, pp. 110–112 and (discussion) 112–114, 2 figs. Cost of aeronautic power plants per horsepower materially lower than that of ship power plants and airplane reliability compares well with safety of other modes of travel; development outlined; supercharger drive and recently developed propeller reduction gears of Wasp engine are described; outline of procedure in developing new model of engine.

Diesel. When the Diesel? E. T. Vincent. West. Flying, vol. 6, no. 2, Aug. 1929, pp. 46–47 and 160. Problems that need to be solved before Diesel engine can be considered in position to displace gasoline engines are discussed; thermodynamic and combustion efficiency; power output limited by air drawn in per stroke, efficiency of cycle, efficiency of combustion, mechanical losses, speed of revolution, and cycles of operations; table gives performance of various types of high-speed oil engines.

Radial vs. In-Line. Radial Versus In-Line Engines, G. D. Angle. Am. Soc. Mech. Engrs.—Advance Paper for mtg. May 27–29, 1929, 19 pp. Present airplane-engine situation; history of radial and in-line crankcase; far greater damage done to lower in-line crankcase than to radial's lower cylinders in landing-gear collapse; record flights with both engines; comparisons as regards weight per horsepower, cost, smoothness of operation, installation, service, visibility, cooling and head resistance; radial engine superior in weight per horsepower, smoothness of operation, installation, service, and cooling.

Testing. Aero Engine Problems in Flight With Particular Reference to Carburation, R. J. Penn. Roy. Aeronautical Soc.—Jl. (Lond.), vol. 33, no. 221, May 1929, pp. 325–350 and (discussion), 350–356. Problems leading up to final approval of aircraft for flight, methods of testing additional parts of power plant provided by aircraft constructor, and manner of circumventing detuning that occurs the moment airplane engine leaves ground are described; oil, water, and gasoline systems; ignition; carburetors and carburetion; effect on carburetion of high altitude flying; balancing and altitude control; features of three carburetors; factors affecting economy in flight.

Type Testing of Commercial Airplane Engines of Medium Power, H. K. Cummings. Aeronautical Eng. (A.S.M.E. Trans.), vol. 1, no. 2, Apr.-June 1929, pp. 45–47. Methods of testing airplane engines employed by Navy Department are described; determination of sea-level performance characteristics of engine; 50-hr. endurance run; redetermination of sea-level performance characteristics; complete teardown and inspection of engine; torque stand described.

Water-Cooled. Jacketed Cylinder Engines, L. F. R. Fell. Times Trade and Eng. Supp. (Lond.), vol. 24, no. 576, July 20, 1929 (Aero Sec.), p. 13. Advantages of liquid-cooled engines and their future in aviation are discussed; thermodynamic advantage of cylinder with equalized temperature throughout combustion-chamber walls; fuel economy; lower maintenance costs; use of ethylene glycol developed in United States, which raises boiling point from 212 deg. fahr. to 388; evaporative cooling system.

AIRPLANE EXHIBITIONS

London. Air-Cooled Engines and Metal Planes Dominate London Aero Show Held for the First Time After an Interval of Ten Years, A. H. Tiltman. Automotive Industries, vol. 61, no. 6, Aug. 10, 1929, pp. 192–195, 10 figs. Noticeable progress seen in design of power plants, with display of compression-ignition type unit marking new phase; comparatively few American craft exhibited; summary of principles in design; brief description of deHaviland "Gypsy" and "Moth," Saunders "Cutty Sark," etc.

AIRPLANE MANUFACTURE

Heat Treatment. Metallurgy Discloses Value of Alloys in Airplane Manufacture, C. B. Phillips. Iron Trade Rev., vol. 85, no. 6, Aug. 8, 1929, pp. 325–327, 4 figs. Methods employed by Fairchild Airplane Manufacturing Corp. for producing planes and engines; more than 10 different alloy steels used; heat treating facilitates use of lighter weight alloys for fuselage construction by imparting greater strength; operations and metals used are outlined.

Welding. Autogenous Welding in Airplane Construction, L. Kuchel. Nat. Advisory Committee for Aeronautics—Tech. Memo., no. 523, July 1929, pp. 1–8, 8 figs. Autogenous welding of fuselage wings, tail surfaces, engine mount, and landing gear is described with reference to welding steel-tube framework of twin-engined Albatros 8-passenger commercial plane; inspectors must be able to tell difference between a good weld and one that simply adheres or is burned. From Schweissen, Schneiden und Metallspritzen mittels Acetylen, 1927.

AIRPLANE MATERIALS

Metals. Metals Used in Airplane Making, G. S. Herrick. Iron Age, vol. 124, no. 4, July 25, 1929, pp. 211–214, 7 figs. Description of various metals used in manufacturing airplanes; increasing volumes of chrome-molybdenum, nickel, and high-carbon steels and aluminum alloys employed; chrome-molybdenum steel most used; fuselage coverings; black sheet stampings; steel cord and tie rods for bracing; strength and resistance to corrosion most important factors in materials for airplane construction.

Tubing. Curves Showing Column Strength of Steel and Duralumin Tubing, O. E. Ross. Nat. Advisory Committee for Aeronautics—Tech. Notes, no. 306, May 1929, 12 pp., 15 figs. Set of column strength curves are given which are intended to simplify method of determining size of struts in airplane structure when load in member is known, and to simplify checking of strength of strut knowing size and length; weight of chrome-molybdenum streamline tubes can be determined since streamline tube has same cross-sectional area as its basic round tube.

AIRPLANE PROPELLERS

Model. Tests on Model Propellers, J. L. Hodgson. Roy. Aeronautical Soc.—Jl. (Lond.), vol. 33, no. 223, July 1929, pp. 615–630, 14 figs.

NOTE.—The abbreviations used in indexing are as follows:

Academy (Acad.)	Engineer (Engr.[s])	Machinery (Machy.)	Record (Rec.)
American (Am.)	Engineering (Eng.)	Machinist (Mach.)	Refrigerating (Refrig.)
Associated (Assoc.)	Gazette (Gaz.)	Magazine (Mag.)	Review (Rev.)
Association (Assn.)	General (Gen.)	Marine (Mar.)	Railway (Ry.)
Bulletin (Bul.)	Geological (Geol.)	Materials (Matls.)	Scientific or Science (Sci.)
Bureau (Bur.)	Heating (Heat.)	Mechanical (Mech.)	Society (Soc.)
Canadian (Can.)	Industrial (Indus.)	Metallurgical (Met.)	State names (Ill., Minn., etc.)
Chemical or Chemistry (Chem.)	Institute (Inst.)	Mining (Min.)	Supplement (Supp.)
Electrical or Electric (Elec.)	Institution (Instn.)	Municipal (Mun.)	Transactions (Trans.)
Electrician (Elecn.)	International (Int.)	National (Nat.)	United States (U. S.)
	Journal (Jl.)	New England (N. E.)	Ventilating (Vent.)
	London (Lond.)	Proceedings (Proc.)	Western (West.)

Results of tests to obtain general idea as to performance of propeller when it was moved at various speeds forward and backward along its axis of rotation, and to express this information in some simple way, so that approximate performance of any similar propeller working in fluid medium of any density might readily be deduced; method of making model propeller investigation of relation between thrust ratio of lifting screws and number, arrangement, shape and section of their blades. Paper presented before Instn. Automobile Engrs., Mar. 1917.

AIRPLANES

Brakes. Pneumatic Braking and Steering Device for Landing Airplanes, F. Castner. Eng. Progress (Berlin), vol. 10, no. 7, July 1929, pp. 183–184, 3 figs. Wheel brake operating pneumatically has been thoroughly tested and found to be entirely dependable, it shortens rolling distance in landing and renders effective steering possible by braking two wheels unequally.

The Use of Wheel Brakes on Airplanes, T. Carroll and S. J. DeFrance. Nat. Advisory Committee for Aeronautics—Tech. Notes, no. 311, July 1929, 9 pp., 6 figs. Results of tests to determine effect of wheel brakes on landing run of airplane, under various conditions of load, and at various wind velocities, are presented; Douglas M-3 plane equipped with internal expanding type of wheel brake with specially devised mechanism for operation differentially by pedals; tail wheel; advantages of use of brakes in reducing landing run and in increasing facility of ground maneuvering; methods of operation and application.

Drag Testing. Determination of Structural Airplane Drag. Air Corps Information Cir., vol. 7, no. 629, Nov. 24, 1928, 24 pp., 37 figs. Information is given which will be useful in predicting maximum level speed; equivalent structural flat plate area determined from actual measured high speed in level flight and design characteristics of several representative airplanes of each type; calculation of total, wing-cellule, and structural drag and parasite area.

Landing Lights. Influence of Landing Lights on Air Speeds, E. A. Sipp. Airway Age, vol. 10, no. 8, Aug. 1929, pp. 1215–1217, 6 figs. Description of tests of landing lights which have shown importance of shape and mounting positions; many mountings tried; tests by J. Doolittle; retractable installations; streamlining most effective.

Landing Speeds. An Analysis of Airplane Landing Speeds, E. G. Reid. Aviation, vol. 27, no. 3, July 20, 1929 (Aeronautical Eng. Sec.), pp. 192–194, 2 figs. Landing-speed situation is examined in some detail; absurdity of many of published performance characteristics of our present commercial airplanes; values of lift coefficients at landing speed studied; airplanes do not attain their maximum lift coefficients in landing; wing loading-landing speed curves are given.

Monoplane vs. Biplane. Monoplane or Biplane, W. S. Farren. Roy. Aeronautical Soc.—Jl. (Lond.), vol. 33, no. 223, July 1929, pp. 490–517 and (discussion) 517–540, 10 figs. For commercial airplanes of between 15,000 and 40,000 lb. in total weight, biplane arrangement developed mainly in Great Britain has on whole an advantage; choice between monoplane and biplane is influenced by stalling speed selected; 20 per cent of paying load of machine lost if present-day commercial biplane were transformed into monoplane; performance, stability and control, wing structure, weight, and torsional strength and rigidity of wing structures are compared.

Performance Testing. Experimental Test Flying, C. F. Uwins. Roy. Aeronautical Soc.—Jl. (Lond.), vol. 33, no. 221, May 1929, pp. 400–405 and (discussion) pp. 405–406. Some aspects of work of testing experimental airplanes described; weighing and balancing plane; checking engine throttle and plane undercarriage, tail skid, and center section cross bracing; errors of trim shown in climb; test of controls; lateral and spiral stability and total rear fin surface examined; pitching stability; requirements of rudder and elevators; spinning and diving tests; obtaining performance figures.

Spinning Characteristics. Airplane Spins and Wing Slots, C. B. Harper. Soc. Automotive Engrs.—Jl., vol. 24, no. 1, July 1929, pp. 25–32 and (discussion) 33, 13 figs. Airplane spin is defined and forces and couples involved are described; principle upon which Handley-Page wing slots are operated; advantages of automatic slots for maintaining lateral stability, assisting in control and in take off from restricted areas; importance of accurate fit of auxiliary airfoil to contour of wing; Navy airplanes fitted with slots.

AIRPLANE WINGS

Pressure Distribution. Wind-Tunnel Pressure Distribution Tests on a Series of Biplane Wing Models; Effects of Changes in Stagger and Gap, M. Knight and R. W. Noyes. Nat. Advisory Committee for Aeronautics—Tech. Note, no. 310, July 1929, 13 pp., 23 figs. Effects of changes in forces on each wing of biplane cellule when either stagger or gap is varied are shown in data obtained from distribution tests made in atmospheric wind tunnel; since each test was carried up to 90-deg. angle of attack, results may be used in study of stalled flight and of spinning as well as in structural design of biplane wings.

Slotted. Wings With Nozzle-Shaped Slots, R. Katzmayr. Nat. Advisory Committee for Aeronautics—Tech. Memorandum, no. 521, July 1929, 28 pp., 19 figs. Report of experiments with nozzle-slotted wings begun at suggestion of J. Mickl in Vienna Aeromechanical Laboratory; effect of air flowing from nozzle-shaped slots is similar to effect produced in case of ordinary slotted wings; high lift values attained at smaller angles of attack employed in ordinary flight; drag values only little greater than for wings of simpler construction; number and location of slots in wing profile greatly affect their aerodynamic action. Translated from Berichte der Aerodynamischen Versuchsanstalt in Vienna, vol. 1, no. 1 (1928).

Torsion. Torsional Rigidity of Cantilever Wings With Constant Spar and Rib Sections, G. Gabrielli. Nat. Advisory Committee for Aeronautics—Tech. Memorandum, no. 520, July 1929, 39 pp., 20 figs. Influence of union of spars and ribs on torsional rigidity of cantilever wing; calculations carried out for two-spar wing of constant cross-section, in which ribs are replaced by continuous member of constant rigidity; bending rigidity of ribs assumed to be very great in comparison with their torsional rigidity, as is case in actual practice; differential equations of spar system on assumption of inflexible ribs; distortion is result of difference in deflection of two spars. Translated from Luftfahrtforschung, June 26, 1928.

AIRPORTS

Fire Prevention. Fire Protection for Municipal Airports, H. E. Newell. Nat. Fire Protection Assn.—Proc. of mtg. May 13–16, 1929, pp. 116–123. Factors to consider in determining fire protection equipment for airports.

Planning. Planning and Operation of Airports (Flughaefen in Ausgestaltung und Betrieb), C. Pirath. Bautechnik (Berlin), vol. 7, no. 20, May 10, 1929, pp. 287–292, 15 figs. General discussion of value of airports and their role in aerial transportation; principles of design of elements of airports, such as mooring masts, landing fields and hangars; recent tendencies in airport design; illustrations from European and American practice.

Snow Removal. See SNOW REMOVAL.

AIRSHIPS

Mooring. Mooring Masts and Landing Trucks for Airships, C. E. Rosendahl. Soc. Automotive Engrs. Jl., vol. 25, no. 1, July 1929, pp. 34–38. Needs for better airship terminal facilities are outlined; advantages of sub mast over high mast for mooring; use of mobile stub mast; better hangar design and study of gusts of wind will facilitate airship development.

Non-Rigid. Design, Construction, and Handling of Non-Rigid Airships, T. L. Blakemore, J. F. Boyle and N. Meadowcroft. Aeronautical Eng. (A.S.M.E. Trans.,) vol. 1, no. 2, Apr.-June 1929, pp. 29–42, 19 figs. Paper previously indexed from Advance Paper for mtg. May 27–30, 1929.

AIRWAYS

Weather Forecasting. Weather and the Airplane, E. H. Bowie. Daniel Guggenheim Fund for Promotion of Aeronautics, Inc.—Paper read July 12, 1929, 27 pp., 10 figs. Study of model weather-reporting service over airway between Los Angeles and San Francisco, sponsored by Fund for year in cooperation with Pacific Telephone and Telegraph Co., Air Services for Army and Navy, Department of Commerce, and Weather Bureau; observing stations and off route; ground signals; determining wind speeds; Tule fog; weather forecasting as aid to automobile traffic and to preventing forest fires.

ALLOY STEEL

Temperature Effects. Effect of Alloying Elements Upon the Stability of Steel at Elevated Temperatures. A. E. White and C. L. Clark. Fuels and Steam Power (A.S.M.E. Trans.), vol. 51, no. 12, May-Aug. 1929, pp. 213–227 and (discussion) 227–228, 90 figs. partly on supp. Methods of investigation are outlined and results of tests are expressed in various curves and tables; six full pages of half-tone prints showing photomicrographs of alloy steels.

ALLOYS

Copper-Tin. See COPPER-TIN ALLOYS.

Industrial Applications. Metals and Alloys for Industrial Applications Requiring Extreme Stability, J. Strauss. Am. Soc. for Steel Treating—Trans., vol. 16, no. 2, Aug. 1929, pp. 191–226, 2 figs. Paper records uses of most widely applied metals and alloys under conditions demanding permanence, either superficial, or otherwise, usually when exposed to active destructive agents, in some form as corrosion, erosion, and elevated temperature; these three agencies are first discussed in detail; various alloys are described, grouped according to element present in their composition in major proportion. Bibliography. Read before West. Metal Congress.

ALUMINUM ALLOYS

Analysis. Preparation of Aluminum Alloys for Microscopic Analysis (Herrichtung von Aluminiumlegierungen fuer die Mikroskopische Untersuchung), H. Choulant. Zeit. fuer Metallkunde (Berlin), vol. 21, no. 6, June 1929, pp. 197–199, 8 figs. Etching media and methods employed for etching of aluminum alloys such as duralumin were investigated, based on which method was developed which is described and recommended; its application to cast alloys and to quenched and annealed duralumin is demonstrated.

Bohnalite. "Bohnalite," A New Light Alloy. Machy. (N. Y.), vol. 35, no. 12, Aug. 1929, p. 946. Brief description of new light-weight alloy suitable for castings and forgings, known as Bohnalite which has been developed by Bohn Aluminum and Brass Corp., Detroit; being light in weight, alloy is particularly suitable for airplane parts; tensile strength, sand cast, of from 28,000 to 45,000 lb. per sq. in.; elastic limit 18,000 to 27,000 lb. per sq. in.

Lautal. Lautal as a Material for Airplane Construction, P. Brenner. Nat. Advisory Committee for Aeronautics—Tech. Notes, no. 524, Aug. 1929, 26 pp., 12 figs. Description of Lautal aluminum alloy without magnesium but containing some copper; production at Lauta Plant of Die Vereinigten Aluminium-Werke A.-G.; use of duralumin and Lautal bolts in detachable and non-detachable joints for airplane structures and methods of riveting, welding and testing them; wing attachments on Junkers planes; tensile tests of heat treatment and working methods; all joints of vital importance in frame should be riveted. From 1928 Yearbook of Deutsche Versuchsanstalt fuer Luftfahrt.

Machine Parts. Aluminum-Alloy Parts in Machine Construction, G. S. Affleck. Am. Mach., vol. 70, no. 26, June 27, 1929, pp. 1013–1014, 3 figs. Some of advantages of aluminum alloys for machine parts are given and certain applications cited; maker of gear shapers uses aluminum-alloy castings for internal working parts of machine to cut down inertia; alloys have increasing use in machine tools as well as in other machines for light moving parts.

ALUMINUM SHAPES

Extruded. Extruded Aluminum Shapes Facilitate Design. Am. Mach., vol. 71, no. 6, Aug. 8, 1929, pp. 236–237, 4 figs. Typical extruded aluminum shapes are illustrated showing how, with this process of production, designer can call for almost any cross-section of metal; sizes of sections can be held to very close limits.

ALUMINUM WELDING

Cans. Aluminum Welding in an Industrial Plant, A. McMillan. Acetylene Jl., vol. 31, no. 1, July 1929, pp. 15–17, 5 figs. Description of methods of welding aluminum cans developed in plant of Shawinigan Chemicals, Ltd. Paper presented before Acetylene Assn. Forum.

AMMONIA

Manufacture. Large Demag Compressors in Works Producing Synthetic Ammonia from Coke-Oven Gas. Demag News (Duisburg), vol. 3, no. 3, July 1929, pp. 54–59, 10 figs. Process of manufacture of synthetic ammonia is explained and details of design of three-stage compressors are given.

AUTOMOBILE AXLES

Testing. Laboratory Testing of Gear Axles, E. Wooler. Soc. Automotive Engrs. Jl., vol. 25, no. 1, July 1929, pp. 68–76 and (discussion) 77, 22 figs. Three laboratory tests made by Timken Roller Bearing Co., Canton, Ohio, for automobile axles are described including deflection test to determine displacement of gears, four-square test of severe wearing, and laboratory road-test in which axle with heavy flywheels is driven by engine; selective sound-testing outfit.

AUTOMOBILE ENGINES

Acceleration. Operating Factors and Engine Acceleration, D. B. Brooks. Soc. Automotive Engrs. Jl., vol. 25, no. 2, Aug. 1929, pp. 130–136 and (discussion) 136 and 141, 22 figs. Results of study of effect of unequal fuel distribution through inlet manifold by running accel-

eration tests on two cylinders at a time; effect of jacket-water temperature with cold inlet manifold and of spark advance; data from laboratory acceleration tests simulating low-gear conditions; deceleration tests recorded by means of spark accelerometer are useful in measuring friction under temperature conditions.

Cylinder Design. Cylinder Head Design, H. R. Ricardo. Automobile Engr. (Lond.), vol. 19, no. 256, July 1929, pp. 257–261, 12 figs. Objects aimed at in author's design of cylinder head for side-valve engine; further investigation of effects of turbulence and detonation; specially designed apparatus employed and results obtained are described; as area of throat or passage connecting combustion chamber proper was reduced, and turbulence and rate of pressure increased, so ratio of compression within detonation limit could be raised; results when degree of indiscriminate turbulence was increased to give nearly 100 lb. per sq. in. per degree of crank-angle pressure rise. (To be continued.)

Design. The Automobile in 1929 (L'automobile en 1929—la rencontre des cycles), E. Marcotte. Arts et Metiers (Paris), no. 105, June 1929, pp. 220–223. Improvement in shape of automobiles, stabilization of types and standardization of mechanism; automatic cleaning of oil; air cooling of engines; motorcycles; future prospects; tendencies in evolution of engines; Diesel engines with automatic injection and with antichambers; incapacity of ordinary automotive engine to consume heavy oil; detonation; carburetors; science of lubrication.

Diesel. See DIESEL ENGINES.

Fuel Economy. The Possibility of Increasing Fuel-Economy, H. M. Jacklin. Soc. Automotive Engrs. Jl., vol. 25, no. 2, Aug. 1929, pp. 159–163, 14 figs. Results of further investigation of operating four-cycle 3 by 4-in. single-cylinder engine, using constant compression at all throttle settings; typical indicator diagrams and curves shown and performance compared; relative performance of car fitted with engine operating under various conditions.

Ignition. Automatic Spark Advance, H. S. Rowell and C. G. Williams. Automobile Engr. (Lond.), vol. 19, no. 256, July 1929, pp. 266–274, 35 figs. Importance of correct spark advance and need for good automatic adjustment of ignition timing; to determine most suitable form of automatic adjustment, principal factors affecting ignition timing are reviewed; various experimental results on diverse engines; exact automatic adjustment is impracticable, and manual control is desirable in addition to any simple automatic system; typical mechanisms for speed control; suggested throttle mechanism for combination with speed control.

Indicator Cards. High-Speed Engine Indicator Tests Recorded on Car While Operating on the Highway, K. J. DeJuhasz. Automotive Industries, vol. 61, no. 4, July 27, 1929, pp. 120–121 and 124, 3 figs. Recent tests conducted on Ford Model A car equipped with DeJuhasz high-speed engine indicator; apparatus makes possible taking of diagrams under actual working conditions, without disturbing normal functions of power plant; apparatus consists essentially of usual type of low-speed engine indicator attached to interrupter valve interposed between engine combustion space and indicator cylinder.

Supercharging. Effect of a Centrifugal Supercharger on Fuel Vaporization, C. F. Taylor. Soc. Automotive Engrs. Jl., vol. 25, no. 1, July 1929, pp. 49–54 and 60, 8 figs. Description of results obtained in investigation made at Massachusetts Institute of Technology to determine whether mechanical action of high-speed centrifugal supercharger improves engine performance by increasing degree of atomization and vaporization of fuel in inlet manifold; tests made on 6-cylinder automobile engine connected to electric cradle dynamometer.

Valve Manufacture. The Manufacture of Valves for Automobile Engines. Machy. (Lond.) vol. 34, no. 876, July 25, 1929, pp. 520–523, 12 figs. Design of automobile engine valves and methods of manufacturing them are described; swaging; annealing and heat treatment; finish machining; grinding valve seats; stems and radius.

Valves. Poppet Exhaust-Valve Design, R. E. Bissell and G. T. Williams. Soc. Automotive Engrs. Jl., vol. 25, no. 2, Aug. 1929, pp. 142–145 and (discussion) 145–147, 41 figs. Design and material used in construction of automotive poppet valves, particularly exhaust valves, are discussed in connection with necessity of resistance of valves to physical and chemical actions of wide variety; methods of cooling; valve-seat functions and design; valve-stem strength and conductivity; guides and spring lock seats; tip design and construction.

AUTOMOBILES

Patents. The Trend of Invention. Automobile Engr. (Lond.), vol. 19, no. 255, June 1929, p. 233, 4 figs. Résumé of more interesting automobile patent specifications, including valve gear, brakes, flywheels, and suspension.

Propeller Shafts. Manufacture and Dynamic Balancing of Automobile Propeller Shafts and the Glaenzer Company (La fabrication et l'equilibrage dynamique des arbes de carden, à la Société Glaenzer), G. Gelanghe. Génie Civil (Paris), vol. 95, no. 3, July 20, 1929, pp. 58–63, 14 figs. Construction of shafts and principal parts of joints; machinery for electric welding and torsion testing; process and equipment of balancing.

AUTOMOTIVE FUELS

Anti-Knock Compounds. Effects of Knock-Suppressing and Knock-Inducing Substances on the Ignition and Partial Combustion of Certain Fuels, R. E. Schaad and C. E. Boord. Indus. and Eng. Chem., vol. 21, no. 8, Aug. 1929, pp. 756–762, 20 figs. Hot-wire ignition curves were determined for toluene, isoamyl acetate, and kerosene between lower and upper limits of fuel-air inflammability; mixtures investigated were produced by vapor-pressure method which is described and shown to be applicable to continuous and reproducible preparation of such series of mixtures.

Research. The Cooperative Fuel Research and Its Results, H. C. Dickinson. Soc. Automotive Engrs. Jl., vol. 25, no. 2, Aug. 1929, pp. 171–174. Causes leading to development of Cooperative Fuel Research Committee; progress made is outlined; conclusions from oil-dilution research; results of engine starting studies; studying knock characteristics of fuel; cooperative fuel-research publications.

B

BEARINGS

Bronze. Bearing Bronze Research Conducted to End Confusion Concerning Suitable Alloy Compositions, E. B. Neil. Automotive Industries, vol. 61, no. 5, Aug. 3, 1929, pp. 150–153, 7 figs. Description of analysis of service stresses made by Bunting Brass and Bronze Co., and Metallurgical Division, Bureau Standards, which is expected to reduce total of specifications; it was found that alloys of high tin and low lead showed highest friction in tests and that as tin was decreased or lead increased friction became progressively lower; wear resistance; equipment used in Izod impact tests.

Bearing Bronzes With and Without Zinc, H. J. French and E. M. Staples. U. S. Bur. Standards—Jl. of Research, vol. 2, no. 6, June 1929, pp. 1017–1038, 22 figs. Based on hardness tests, Izod impact tests, repeated pounding tests, and wear tests, both with and without lubrication, at temperatures within range 70 to 600 deg. fahr., bronzes in copper corner of copper-tin-lead system have been classified according to character of service for which they seem to be best adapted; bronzes with less than 4 per cent tin unsuited for general bearing service; bronzes containing more than 5 per cent lead best able to operate for short periods in absence of lubrication.

Lubrication. The Relation of Theory to Practice in Plain Bearing Lubrication. Lubrication, vol. 15, no. 6, June 1929, pp. 61–72, 18 figs. Empirical rules of friction; Osborne Reynolds' hydrodynamic theory of bearing lubrication; influence of theory on design of thrust bearings; cooling maintains load carrying capacity of oil films; graphical presentation of theory of bearing lubrication; important conclusions drawn from Harrison's and Sommerfeld's work; oil grooving; journal running positions and bearing cap design; relation between load, speed, viscosity, and coefficient of friction.

BOILER CONTROL

Electric. Electric Boiler Regulators (Elektrischer Kesselregler), F. Engel and A. G. S. Sandison. Waerme (Berlin), vol. 52, no. 28, July 13, 1929, pp. 533–537, 8 figs. Two regulating systems are discussed; in one, pressure drop in superheater is utilized as motive force; second process keeps pressure in pipe lines uniform; details of Electroflo regulator.

BOILER DESIGN

Feed Circuits. Modern Feed-Water Circuits, J. G. Weir. Instn. Mech. Engrs.—Proc. (Lond.), no. 1, Jan. 1929, pp. 5–21 and (discussion) 22–32, 22 figs. Characteristics of various feedwater circuits are considered with diagrams; methods of controlling amount of distribution of working fluid in boiler; construction of direct-contact feedheater and deaerator; various arrangements of feed heaters to increase thermal efficiency of practical feed cycle; make-up feed and correct pressure data to employ; system with low-pressure evaporation; methods of reheating steam.

BOILER FURNACES

Refractory Materials. Refractories Service Conditions in Furnaces Burning Anthracite on Traveling Grate Stokers, R. A. Sherman, E. Taylor and H. S. Karch. Fuels and Steam Power (A.S.M.E. Trans.), vol. 51, no. 12, May-Aug. 1929, pp. 183–196, 17 figs. Object of investigation was to obtain data on service conditions which govern life of refractories in these furnaces and in particular to study nature of slag action; conditions investigated were: temperature, composition, and velocity of furnace gas, temperatures of refractories; amount and composition of solids carried in furnace gas.

BOILER HEADS

Design. The Strength of Dished Ends, E. Hoehn. Engineering (Lond.), vol. 128, no. 3312, July 5, 1929, pp. 1–4, 10 figs. It has been usual to fix thickness of dished end by assuming that major portion of plating forms part of spherical shell; author shows conclusively irrationality of formulas based on this hypothesis and claims that much better agreement between calculation and experience is obtained by regarding such ends as approximating to section of ellipsoid; he has measured strains on length of 20 mm. with instruments reading to 1/1000 mm., and has mapped out very completely character of stresses as developed at external faces of ten dished ends.

BOILERS

Gas Producer. Boiler Furnaces of Gas-Producer Type. Power Engr. (Lond.), vol. 24, no. 281, Aug. 1929, pp. 318–319 and 325, 5 figs. Proposal to fire boilers on "producer" lines is half century old but development has been hindered by obsession that only small diameter horizontal type furnace could be considered; general advantages of producer firing summarized.

Pulverized-Coal-Fired. Coal Dust Firing for Boilers and Industrial Furnaces, H. Berg and E. Vogt. Inst. of Fuel—Jl. (Lond.), vol. 7, no. 7, Apr. 1929, pp. 240–249 and (discussion) 249–257, 16 figs. Enumeration and successful application of pulverized coal for melting furnaces, heat treatment, and steam production; tabular data on coal-dust firing furnaces in Continental practice.

Evolution of Slag Tap Furnace at Charles R. Huntley Station of Buffalo General Electric Company, H. M. Cushing. Fuel (Lond.), vol. 8, no. 7, July 1929, pp. 311–321, 12 figs. Slag-tap furnace, first used at station in Buffalo about 3 years ago, has played important part in development of powdered-coal-fired furnace; 14 furnaces so equipped are in daily operation and 20 more are in process of manufacture; it requires minimum of building volume; will burn efficiently and at high ratings an unusually wide variety of coals; produces quick ignition of fuel; prevents infiltration of air; requires minimum of ash-handling labor, etc.

Water-Tube. Bailly-Mathot Boilers at the Droogenbosch Power Station. Engineer (Lond.), vol. 148, no. 3836, July 19, 1929, pp. 74–75, 3 figs. Plant now contains 16 boilers each rated at 33,000 lb. per hour evaporation, bringing rated capacity of plant up to 47,950 kw., replacing four hand-fired units with rated evaporative capacity of only 8600 lb. per hr.; detailed results of tests are given.

C

CADMIUM

Plating With. Cadmium Plating, H. C. Pierce. Metal Industry (N. Y.), vol. 27, no. 8, Aug. 1929, pp. 373–374. Value of this process for resistance to corrosion is pointed out; statistical analysis of production of cadmium showing that it has increased more than 10 times in past ten years; properties of cadmium coating are given and plating process is explained.

CARBON-DIOXIDE COMPRESSORS

Circulation in. Mass Circulation in Carbon Dioxide Machines, H. Mawson. Ice and Cold Storage (Lond.), vol. 32, no. 377, Aug. 1929, pp. 197–199, 4 figs. Refrigeration produced by machine working between definite temperature limits is dependent upon mass of carbon dioxide compressed and circulated per unit time; multi-effort compression cycle; compound compression cycle; results of tests. Read before Institution of Mech. Engrs.

CERAMIC KILNS

Firing. Kilns and Kiln Firing, S. R. Hind. Ceramic Soc.—Trans. (Lond.), vol. 28, no. 6, June 1929, pp. 316–332, 6 figs. General description and principles of kiln; method of heating; fuel consumption; output advantages; experimental data.

CHIMNEYS

Venturi. Design and Test of a Venturi Stack, A. J. Stepanoff. Fuels and Steam Power (A.S.M.E. Trans.), vol. 51, no. 12, May-Aug. 1929, pp. 197–199, 9 figs. Results of tests on stack operating on Venturi or ejector principle through which gaseous products of combustion are discharged for purpose of inducing proper draft; tables showing gas temperatures at fan discharge and stack top for various nozzle arrangements and steam-jet induced draft; draft and discharge curves.

COAL ANALYSIS

Heat Energy. Influence of Coal Type on Radiation in Boiler Furnaces, W. J. Wohlenberg and R. L. Anthony. Fuels and Steam Power (A.S.M.E. Trans.), vol. 51, no. 12, May-Aug. 1929, pp. 235–243 and (discussion) 244–246, 34 figs. Results of application of methods and data presented in A.S.M.E. paper ("Influence of Radiation in Coal-Fired Furnaces on Boiler-Surface Requirements, and a Simplified Method for Its Calculation," W. J. Wohlenberg and E. L. Lindseth) to pulverized coal for number of coals of widely varying composition; it was found that calorific value serves as most consistent and useful indicator of radiation powers of coal as burned in pulverized form in boiler furnaces.

COAL CARBONIZATION

Coking. The Coking of Coal, M. Barash. Chem. and Industry (Lond.), vol. 48, no. 28, July 12, 1929, pp. 174t–183t. See also Gas Jl. (Lond.), vol. 187, no. 3452, July 17, 1929, pp. 137–140. Summary of series of investigations carried out by author during last decade into influence of certain constituents of coal and influence of certain treatments of coal upon conversion of coal into coke; review of number of recent publications dealing with coking of coal, object being to indicate extent to which deductions drawn from above investigations have been confirmed.

COAL CARBONIZATION, LOW-TEMPERATURE

Bussey Process. Bussey Coal Distillation Plant. Gas Jl. (Lond.), vol. 187, no. 3453, July 24, 1929, pp. 188–189, 2 figs. Description of large installation at Glenboig, Scotland, consisting of 14 vertical retorts, which operate according to Bussey process.

Coalite Process. Askern Coalite Works. Colliery Guardian (Lond.), vol. 139, no. 3576, July 12, 1929, pp. 131–132, 5 figs. Brief description of plant near Doncaster, second commercial plant erected in England to use coalite process; four batteries, each with 36 retorts, capacity 90,000 tons coal per annum; completion of second section will double capacity; carbonization period is 4 hr. and retort temperature 600 deg. cent.

Maclaurin Process. Low-Temperature Carbonization at Glasgow, C. H. Lander. Gas World (Lond.), vol. 91, no. 2346, July 20, 1929, p. 61. Report by Director of Fuel Research of Department of Scientific and Industrial Research of Maclaurin plant with rated capacity of 100 tons of coal per day.

The Maclaurin Low-Temperature Process—Fuel Board Report on Dalmarnock Plant. Colliery Guardian (Lond.), vol. 138, no. 3572, June 14, 1929, pp. 2299–2301, 2 figs. Plant at Glasgow has five units, each with rated capacity of 20 tons coal per day; description of test of one unit; yields per ton of dry coal were 12.12 cwt. coke, 17.8 gal tar, 1.5 gal. crude gas spirit, 33,160 cu. ft. gas, 48.1 gal. liquid and 41.9 lb. ammonium sulphate.

Pehrson Process. The Pehrson Process for the Low-Temperature Carbonization of Coal, W. R. Chapman. Chem. and Industry (Lond.), vol. 48, no. 28, July 12, 1929, pp. 189t–194t, 5 figs. Process is carried out in metallic retorts design of which is based on that of Pehrson rotary drier, which is illustrated; when drum rotates material mounts up side on louvres and overlapping of louvre plates prevents any of material resting on them from falling backward into gas channels.

COAL PULVERIZERS

Analysis of. Coal Pulverizers, W. J. A. London. Fuels and Steam Power (A.S.M.E. Trans.), vol. 51, no. 12, May-Aug. 1929, pp. 159–165 and (discussion) 165–166, 11 figs. Analysis of what actually takes place in mill leads to suggested design of mill to give maximum impact; types of impact mills; chart of tests, giving fineness performances; how fine pulverization is produced in impact mills; guarantees; chart plotted from Ashley steel-plant tests; curve of average power consumption per ton of one mill.

COMBUSTION CONTROL

Automatic. Automatic Combustion Control Improves Boiler Operation, M. W. Horley. Power, vol. 69, no. 26, June 25, 1929, pp. 1043–1046, 5 figs. Without use of preheaters on economizers average of 78 per cent boiler and furnace efficiency is maintained in Pennsylvania Water and Power Co.'s steam plant at Holtwood, Pa., at average of 250 per cent boiler rating when burning combination of pulverized and anthracite river coal.

COMPRESSED AIR

Flow Meters. Flow Meters for Compressed Air. Colliery Guardian (Lond.), vol. 138, no. 3571, June 7, 1929, pp. 2210–2211, 3 figs. Description of Askania measuring installation for compressed air, meter is so designed that it bypasses, from main flow, volume of air which is always in fixed ratio to main flow.

COPPER-TIN ALLOYS

Crystal Structure. Note on Crystal Structure of the Alpha Copper-Tin Alloys, R. F. Mehl and C. S. Barrett. Am. Inst. Min. and Met. Engrs.—Tech. Pub., no. 231, for mtg. Sept. 1929, 6 pp., 2 figs. Side of unit face-centered cube and density were determined for three alloy compositions in alpha field of copper-tin system; it is shown, contrary to previously published work, that this solid solution is simple substitutional in type.

CUTTING TOOLS

Design. Design of Cutting Edge and Its Importance in Chipping (Die Geometrie der Schneide und ihre Bedeutung fuer die Zerspanung), E. Simon. Werkstattstechnik (Berlin), vol. 23, no. 12, June 15, 1929, pp. 357–364, 15 figs. Cutting pressure; free and impeded formation of chip; dependence of cutting pressure of chip area in both cases; controversies in test results cleared by decomposition of cutting pressures; cutting pressure on cutting edges. Bibliography.

Hard Metals. Usage of Hard Metals in Germany (Die Verwendung von Hartmetallen in Deutschland), G. Schlesinger. Werkstattstechnik (Berlin), vol. 23, no. 13, July 1, 1929, pp. 381–387, 23 figs. Development from high-speed steel to tungsten-carbide and carboloy steels; weak point and cutting efficiency of high-speed steel, stellite, and tungsten carbide; influence of increase of cutting speed on tools and machine-tool design.

S. O. B. V. A New English Cutting Metal. Machy. (N. Y.), vol. 35, no. 12, Aug. 1929, p. 910. Results of tests to show possibilities of new cutting metal known as S.O.B.V. cutting alloy which has been carried out by Samuel Osborn and Co., Sheffield, England; steel cut at 280-ft. surface speed per min.; low speed and coarse feed test; removing metal at rate of 1320 lb. per hour.

D

DESUPERHEATERS

B. & W. The De-Superheating of Steam, C. C. Pounder. Mech. World (Manchester), vol. 86, no. 2218, July 5, 1929, pp. 3–5, 3 figs. Problems of providing saturated steam for auxiliary plants on board ship discussed; for important water-tube boiler installations it becomes necessary to withdraw steam for auxiliary purposes from main superheated steam line and to desuperheat it; design of Babcock and Wilcox's desuperheater is described.

DIES

Blanking. Finding Center of Pressure of Blanking Die. Machy. (Lond.), vol. 34, no. 873, July 4, 1929, p. 426, 1 fig. Method is described for finding center of pressure of blanking die which is necessary for locating center of pressure in line with center of ram.

Shaving. The Function and General Design of Shaving Dies, E. E. Clark. Metal Stampings, vol. 2, no. 7, July 1929, pp. 525–528 and 537–538, 7 figs. Use of shaving dies to eliminate expensive grinding and filing operations in producing stampings with smooth edges; construction and design feature for such dies.

DIESEL-ELECTRIC POWER PLANTS

Berlin, Germany. Floating Power Stations, E. Kammerer. Eng. Progress (Berlin), vol. 10, no. 8, Aug. 1929, pp. 205–206, 2 figs. Power plant described is constructed by Allgemeine Elektricitaets-Gesellschaft, Berlin, to supply energy where only temporarily required as in construction work; plant is equipped with three Diesel-electric sets, each developing 150 hp.; its total output is 375 kva.; three-phase current generated has tension of 400 volts at 50 periods.

DIESEL ENGINES

Automotive. Linke Diesel Engine for Automobiles (Moteur Diesel, système Linke, pour automobiles), G. Delanghe. Génie Civil (Paris), vol. 94, no. 26, June 29, 1929, pp. 619–620, 6 figs. Four-stroke Linke Diesel engine with mechanical injection is described; 1200 r.p.m. normally developed; 4 cylinders; electric starting system; results of tests on torque stand with Linke engine developing 50 hp.

Sunbeam Diesel-Type Engine. Automotive Industries, vol. 61, no. 5, Aug. 3, 1929, p. 153, 1 fig. High-speed compression-ignition Diesel engine, developed by Sunbeam Motor Co., primarily for aircraft, but capable of being adapted for use in trucks, is briefly described; bore and stroke of 6 cylinders are 120 and 130 mm., respectively; 100 hp. developed at 1500 r.p.m.

A Survey of Automotive Diesel Types. F. Johnstone-Taylor. Oil Engine Power, vol. 7, no. 8, Aug. 1929, pp. 562–565, 7 figs. Two classes of engine are low weight per horsepower, used primarily in aircraft and rail motor-car work, and small engines of cast-iron construction; description and illustration on Beardmore, Vickers-Armstrong, M.A.N., Benz, and Bagnulo.

Design. The GMA Airless-Injection Four-Stroke Diesel Engine, F. Kohlhauser. Eng. Progress (Berlin), vol. 10, no. 8, Aug. 1929, pp. 215–217, 7 figs. New engine designed by Waggon- und Maschinenbau-Aktiengesellschaft Goerlitz, Goerlitz developing 650 b.hp.; instead of usual arrangement of push-rods and rocker arms for operating valves, latter are controlled hydraulically by oil under pressure; in this way, not only does whole of valve mechanism become simpler and appearance of engine more pleasing, but also stresses in valve motion and power required for operating valves are considerably reduced.

DRILLING MACHINES

Feeds. Pressure Charts for Thrust Bearing Design. Machy. (Lond.), vol. 34, no. 877, Aug. 1, 1929, pp. 568–570, 5 figs. Results of tests made to determine feeding pressure necessary to force drills through different kinds of materials.

E

ELECTROPLATING

Spotting Out. The Spotting of Plated or Finished Metals. W. P. Barrows. U. S. Bur. Standards—Jl., of Research, vol. 2, no. 6, June 1929, pp. 1085–1116, 3 figs. Results of investigation of spotting out of plated finishes described; occurrence and composition of crystal spots; methods of test and plant tests outlined; occurrence and composition of stain spots; methods of test; plant tests; effective remedies for both cases recommended.

ENAMELING

Steel. Pickling Steel for Vitreous Enameling, F. G. Jaeger. Metal Cleaning and Finishing, vol. 1, no. 3, July 1929, pp. 299–302. Description of pickling methods used in preparation of articles for vitreous enameling; economics practised; use of niter cake; pickle bath agitators; fume eliminating reagents.

F

FEEDWATER ANALYSIS

Standard Method. Standard Methods of Water Analysis, H. Farmer. Fuels and Steam Power (A.S.M.E. Trans.), vol. 51, no. 12, May-Aug. 1929, pp. 90–93, 5 figs. Report presents tentative method for determination of dissolved oxygen in boiler feedwater; application of test; Winkler method for determining dissolved oxygen; summary of reagents; collection of sample; adding reagents; titrating sample; calculations; apparatus; tolerances.

FEEDWATER HEATING

Improved System. An Improved System of Feed-Water, A. S. Willis. Mech. World (Manchester), vol. 84, no. 2222, Aug. 2, 1929, pp.

107–108, 2 figs. Advantages of feedwater heating with brief description of improved system which utilizes waste heat with saving of from 10 to 15 per cent in fuel consumption.

FEEDWATER REGULATION

Thermo Hydraulic. New Thermo Hydraulic Feedwater Regulator. Instruments, vol. 2, no. 7, July 1929, pp. 255–256, 2 figs. Thermo-hydraulic feedwater regulator which embodies new and improved features developed by Bailey Meter Co. is described.

FEEDWATER TREATMENT

Deconcentration. Deconcentration: An Aspect of Boiler Control. Chem. Age (Lond.), vol. 20, nos. 515 and 516, May 11 and 18, 1929, pp. 443–444 and 465–466. May 11: However much attention be paid to softening or other pretreatment of boiler water, progressive increase in its content of soluble salts still requires attention; exhaustive discussion of this aspect of boiler control is given; softening; salt transference; priming and foaming; conditions upon which foaming depends; increase in saline concentration; control of concentration; evaporation of makeup. May 18: Intermittent or periodical blow-down, economic aspect.

FURNACES, HEAT-TREATING

Gas Fired. Low Pressure Gas Apparatus for Temperatures Up to 1000 Deg. Cent., G. R. Hems. Gas World (Lond.), vol. 91, no. 2346, July 20, 1929 (Industrial Gas Supp.), pp. 101–104, 4 figs. Details of design are presented for furnaces for ferrous and non-ferrous annealing operations, steel reheating, enameling and other uses.

G

GAGES

Nitridation. Nitriding Oil Tool Gages, F. W. Curtis. Am. Mach., vol. 70, no. 22, May 30, 1929, pp. 863–864, 5 figs. Description of nitriding process for large thread gages which eliminates difficult grinding operation and produces hard surface free from scale; tool joint made by Doheny Stone Drill Co. is discussed; case-hardening by nitriding process can be done by small shop with inexpensive equipment.

GAS PLANTS

Corrosion. Corrosion and Protection of Metals in Gas Plants (Korrosion und Metallschutz im Gaswerksbetrieb), Maass. Gas u. Wasserfach (Munich), vol. 72, no. 23, June 8, 1929, pp. 573–578, 16 figs. Data from practice on corrosion of piping, roofs, scrubbers, and other elements of gas plants; use of lead, copper, bronze, zinc, and other materials for corrosion protection.

GAS TURBINES

Lorenzen. The C. Lorenzen Gas Turbine, A. Heller. Eng. Progress (Berlin), vol. 10, no. 2, Feb. 1929, pp. 46–48, 6 figs. Results of tests obtained on exhaust-gas turbine at German Aeronautics Test Laboratory; exhaust-gas turbines for motor vehicles; live-gas turbines for power purposes.

GEARS

Grinding. The Production and Application of Ground Gears, H. F. L. Orcutt. Automobile Engr. (Lond.), vol. 19, no. 255, June 1929, pp. 230–231 and (discussion) 231–232, 3 figs. See also editorial p. 195. Gear-tooth grinding is sufficiently advanced to prove that technical demands are almost wholly those of accuracy of tooth finish; this accuracy is limited to variations in tooth form, from 0.0002 in. in small gears to 0.001 in. or 0.002 in. in large gearing; process on machine employing formed-wheel method of grinding gears is outlined; index mechanism. Paper presented before joint meeting of Instn. Automobile Engrs. with Instn. Production Engrs.

Variable-Speed. Varatio Variable Speed Gears. Elec. Times (Lond.), vol. 76, no. 1969, July 18, 1929, p. 95, 2 figs. Equipment described appears to be definite step forward toward mechanism enabling any number of speeds to be obtained between certain limits; enabling large horsepower to be transmitted.

GLASS MANUFACTURE

Telescope Reflector. Making the Glass Disk for a 70-Inch Telescope Reflector, A. N. Finn. Indus. and Eng. Chem., vol. 21, no. 8, Aug. 1929, pp. 744–750, 7 figs. Details are given of procedure followed in making glass disk 70 in. in diameter and 11 in. thick for use as reflector in astronomical telescope; these include making of pots, modifications in construction of mold and annealing furnace, methods of measuring and controlling temperatures, melting and casting of glass, essential data on annealing glass, determination of quality of annealing, and drilling of hole to accommodate Cassegrainian mounting.

H

HEAT-INSULATING MATERIALS

Mineral Wool. Mineral Wool, J. R. Thoenen. U. S. Bur. of Mines—Information Cir., no. 6142, June 1929, 13 pp. Description and uses; classed as rock wool and slag wool; history of industry; slag handling, mining, and manufacturing practice; finished products, suited to special uses, descriptions of plants in Indiana, Illinois, and New Jersey; discussion of details of fusing raw material, blowing, and collection of blown wool; typical analyses; production statistics.

HEAT TRANSMISSION

Analytical Study. Effect of Temperature Fields on Boundary Layers (Die Beeinflussung von Grenzschichten durch Temperaturfelder), J. Schmekel. Zeit. fuer Angewandte Mathematik und Mechanik (Berlin), vol. 9, no. 2, Apr. 1929, pp. 101–109. Observations of Soennecken and Stender on cooling of a tube in fluid stream are studied; it is shown how differences can be calculated on basis of Prandtl theory; nature of fluid motion is discussed and it is shown that especially for smooth plane wall periodic disturbances occur; criterion for magnitude of critical Reynolds coefficient and origin of turbulence through natural heating is given.

HELICOGYRE

Description. Helicogyre, V. Isacco. Roy. Aeronautical Soc.—Jl. (Lond.), vol. 33, no. 223, July 1929, pp. 573–599 and (discussion) 599–614, 31 figs. Planes built and experimented with up to present time; aerodynamic analysis of single sustaining propeller in translation; articulation of wings of helicogyre in all directions; variation of wing incidence; horizontal translation; stability; position of engines on wings; comparison of helicogyres with airplanes in regard to stand still at fixed point, horizontal translation, safety in flight, and landing, fatigue of parts, and commercial qualities of helicogyres; practical results already obtained.

HELIUM PRODUCTION

Amarillo Plant. Helium Plant at Amarillo Operates at Line Pressure. Oil Field Eng., vol. 6, no. 2, Aug. 1929, p. 23, 1 fig. Gas passed through plant is obtained from four wells ranging in depth from 3300 to 3700 ft.; helium is 95 to 98 per cent pure and volume of 2,000,000 to 2,500,000 cu. ft. is treated per day.

HYDRAULIC TURBINES

Efficiency. Hydraulic Efficiency of Large Gap, Full Admission Impulse Hydraulic Turbines (Der hydraulische Wirkungsgrad grosspaltiger Vollstrahlwasserturbinen), H. Baudisch. Electrotechnik u. Maschinenbau (Vienna), vol. 47, no. 29, July 21, 1929, pp. 621–622. Mathematical analysis.

I

INDUSTRIAL LIGHTING

Artificial. Artificial Lighting Provisions in Building Design and Process Layout, W. Harrison. Mgmt. (A.S.M.E. Trans.), vol. 51, no. 9, Jan.-Apr. 1929, pp. 78–81, 12 figs. Author points out that, since daylight provides adequate illumination for only about one-half of working area in modern multistory factory building, artificial illumination is essential for effective use of entire space for productive purposes; procedure for correct design of such systems is outlined.

Natural. Designing Buildings for Daylight, H. H. Higbie and W. C. Randall. Mgmt. (A.S.M.E. Trans.), vol. 51, no. 9, Jan.-Apr. 1929, pp. 61–75 and (discussion) 75–78, 28 figs. Outline of method by which amount and distribution of daylight illumination that should be produced by any specific window arrangement in interior of building may be predicted; method is based upon rigorous theoretical analysis and has been checked repeatedly by field tests upon full-size buildings as well as by laboratory tests upon models of buildings; some results of application of method to analysis of lighting effect of changes in fenestration of typical buildings are discussed. Bibliography.

INDUSTRIAL MANAGEMENT

Dexter Folder Co. Scientific Management and Its Effect Upon Manufacturing, R. M. Meyer. Mgmt. (A.S.M.E. Trans.), vol. 51, no. 9, Jan.-Apr. 1929, pp. 37–42, 8 figs. Three results have followed application of scientific management by Dexter Folder Co., Pearl River, N. Y.; they are: better product offered to trades at lower list price, wages increased, with consequent bettering of standards of living for employees, and greater return on capital invested resulted; design methods, routing, scheduling, inventory control, purchasing, time study, rate setting, maintenance and inspection procedure are described.

New Equipment. Outstanding Economic and Technical Factors Involved in the Engineering of New Manufacturing Equipment, J. R. Shea. Mgmt. (A.S.M.E. Trans.), vol. 51, no. 9, Jan.-Apr. 1929, pp. 49–57 and (discussion) 57–58, 16 figs. Subject is developed under three main headings, (1) economic analysis, (2) technical analysis, and (3) practical applications; economic analysis is essentially summary of various elements of cost involved in proposed manufacturing plan, and final choice of equipment if based on this analysis.

INTERNAL-COMBUSTION ENGINES

See AIRPLANE ENGINES; AUTOMOBILE ENGINES; DIESEL ENGINES; OIL ENGINES.

IRON AND STEEL PLANTS

Ore Handling. Handling and Storing Ore at River Rouge, C. Longenecker. Blast Furnaces and Steel Plant, vol. 17, no. 8, Aug. 1929, pp. 1191–1194, 10 figs. System is described by which ore and other minerals are received and distributed economically and with dispatch from point central to several consuming departments.

J

JIGS AND FIXTURES

Design. Principles of Jig and Fixture Practice, J. W. Roe. Machine-Shop Practice (A.S.M.E. Trans.), vol. 51, no. 13, May-Aug. 1929, pp. 79–87 and (discussion) 87–95, 17 figs. Many principles of jig and fixture design are brought together; economic principles; proposed equipment formulas, and how they may help in deciding tooling up problems as they arise; object of good fixtures is furthered by good work holders or racks for handling work between operations; principles relating to details of design including feeds, clamping, jig legs, jig bushings, and jig latches. Bibliography.

L

LACQUERING

Indoor Service. The Composition, Uses, and Application of Lacquers Suitable for Indoor Service, S. F. Dimlich. Metal Cleaning and Finishing, vol. 1, no. 3, July 1929, pp. 285–288. Brass, bronze, silver and water dip lacquers; metal enamels; mixing, applications and storage of lacquers; production of shaded effects, splatter finishes, duotones, etc.

LATHES

High Speed. High-Speed Lathe-Tool Tests. Am. Mach., vol. 71, no. 4, July 25, 1929, p. 157. Results of tests of tools working on shallow cuts at high speeds, developed by Bureau of Standards are described; methods based upon fact that when two tools are set at equal depths in one tool holder, second or trailing tool will not cut until leader or cutting tool begins to wear; effect of cutting fluids. Abstract from U. S. Bur. of Standards—Jl. of Research.

Roughing. Heavy Roughing Lathe, H. Haneke. Eng. Progress (Berlin), vol. 10, no. 7, July 1929, pp. 188–189, 3 figs. Machine described has swing of 10 ft. diameter and turning length of 33 ft. and is particularly intended for rough turning axles, shafts, crankshafts and similar parts.

LIGHTNING PROTECTION

Revised Code. Report of Committee on Protection Against Lightning, M. G. Lloyd. Nat. Fire Protection Assn.—Proc. of mtg. May 13–16, 1929, pp. 255–294. Revised code for protection against lightning, to supersede similar code adopted to 1924; present text developed by committee under sponsorship of U. S. Bur. of

Standards and Am. Inst. of Elec. Engrs., has been approved as Am. Standard by Am. Standards Assn.

LOCOMOTIVE TERMINALS

Lifting Devices. The Modern Drop Pit Table. H. K. Christie. Baldwin Locomotive, vol. 8, no. 1, July 1929, pp. 37–47, 15 figs. (In English and Spanish.) Development of modern lifting devices for handling locomotives at terminals is discussed; tables are 10 ft. 6 in. each way, giving area of over 100 sq. ft.; it is electrically operated by means of motor which, through protected gears, shafts, and worms, raises and lowers table top.

Oil-Electric. The Internal-Combustion Engine in Railroad Service, S. T. Dodd. Gen. Elec Rev., vol. 32, no. 8, Aug. 1929, pp. 437–445, 10 figs. Advantages of electrically transmitting engine's power to wheels; factors determining choice of gasoline-electric drive for railcars and oil-electric drive for locomotives; tabulated data of increase in number of units in service, performance, and operating costs of gas and oil-electric drive.

LOCOMOTIVES

Pacific. D. and H. Pacific Type Locomotive. Ry. Age, vol. 87, no. 3, July 20, 1929, pp. 201–202, 2 figs. Description of 4–6–2 type locomotive built with streamline effect similar to British design; auxiliaries located below boiler to secure low center of gravity; total engine weight 283,300 lb.; combined heating surfaces 4657 sq. ft.; rated tractive force 41,600 lb.

Passenger. Modern American Express Locomotives, E. C. Poultney. Locomotive (Lond.), vol. 35, no. 442, June 15, 1929, pp. 196–200, 4 figs. Examples of six and eight-coupled locomotives now to be found on many of important railways; refers to principles which govern design, importance of which is largely due to great size and power of recent engines.

Superheater. Improvement of Superheating on Locomotives (L'Amélioration de la surchauffe dans les locomotives), C. Bourrie. Revue Générale des Chemins de Fer (Paris), vol. 48, no. 6, June 1929, pp. 426–440, 8 figs. Type 140A locomotives of Paris, Lyon and Mediterranean Railway with superheated steam of 14 kg. per sq. cm. at 225 degrees, put into service in 1925, had given inefficient performance; after tests, temperature was raised to 350 degrees which has given satisfactory results and has been applied in to other types.

LUBRICATING OILS

Airplane Engines. Fluidity of Aviation-Engine Oils, E. R. Lederer and F. R. Staley. Soc. Automotive Engrs.—Jl., vol. 25, no. 1, July 1929, pp. 44–48 and 77, 7 figs. Discussion of paper published in Feb. 1929, issue of Journal is given, with brief abstract of paper; effect of pressure on viscosity; film-resistance tests with Osborn machine; shearing stress related to film thickness; fluidity of aircraft lubricating oils; fluidity-test relationships inconsistent; question of superiority of paraffin-base oils; all-weather oil-volatility test needed.

Some Pertinent Facts About Aviation Engine Oils, F. R. Staley. Aviation, vol. 27, no. 6, Aug. 10, 1929, pp. 304–305, 3 figs. Properties required of lubricating oils for airplane engines; distillation, chemical treatment, filtration, and dewaxing steps in refining petroleum; viscosity and volatility tests; essentials in manufacture of aviation oil.

M

MACHINE TOOLS

Electric Drive. Electric Equipment in Machine Shops (Elektrische Werkstatteinrichtungen). K. Meller. Maschinenbau (Berlin), vol. 8, no. 11, June 6, 1929, pp. 367–371, 28 figs. Electric drives and motors for machine tools used in metal-working industry and welding equipment exhibited in Leipzig Fair and some of their characteristics are discussed.

Gears. The "Varatio" Variable Speed Gear. Engineer (Lond.), vol. 148, no. 3836, July 19, 1929, pp. 72–73, 2 figs. Description of Varatio transmission made by Variable Power Transmission, Ltd.; how difficulties presented by question of contact is overcome in new design; it is developed in all sizes to transmit power from fraction of horsepower to 1000 hp.; at Britannia Works example of gear has been in regular workshop use for past 18 months, driving equipment of milling, shaping, cutting-off, and other machines.

Leipzig Fair. Machine Tools (Werkzeugmaschinen), H. Behrens. Maschinenbau (Berlin), vol. 8, no. 11, June 6, 1929, pp. 346–361, 50 figs. Preliminary notes, giving details regarding requirements to be met in design of modern and improved machine tools; general review of exhibits at Leipzig Fair.

Welding. Welded Machine Tool Structures, J. R. Weaver. Welding Engr., vol. 14, no. 7, July 1929, pp. 37–38, 6 figs. Some example of variety of machine parts which may be fabricated economically of welded steel.

MATERIALS HANDLING

Accident Prevention. Safe Practices in Materials Handling. Blast Furnace and Steel Plant, vol. 17, no. 8, Aug. 1929, pp. 1204–1206, 10 figs. Various devices used in lifting and transferring materials are discussed with reference to safety recommendations; mechanical means safer than hand labor. Abstract of Safe Practices Pamphlet no. 55 of National Safety Council.

Cost Reduction. Mechanical Handling Brings Lower Unit Costs, H. V. Coes. Factory and Indus. Mgmt., vol. 78, no. 2, Aug. 1929, pp. 227–228. Lack of adequate information concerning capacity, maintenance, fundamental economics, means of coordination and installation of material handling equipment is pointed out.

METALS HARDENING

Cloudburst Method. Hardening and Super-Hardening. Metallurgist (Supp. to Engineer, Lond.), July 26, 1929, pp. 99–100. Discussion of Cloudburst method employed by Herbert in subjecting surface of hardened piece of steel to impact from steel balls allowed to fall upon it; steel in hardest condition put by quenching is yet capable of undergoing plastic deformation by cold working; possible important method of counteracting those surface defects at present limiting useful life of material in service under fatigue conditions.

MILLING MACHINES

Fixtures. Fixtures for Milling Tractor Engine Parts. Machy. (N. Y.), vol. 35, no. 10, June 1929, pp. 730–732, 6 figs. Typical examples of milling fixtures for use in machining connecting rods and bearing caps on production basis in tractor plant are described; milling connecting-rod bosses at rate of 40 per hr.; milling locating pads on connecting-rods; milling valve-lifter guide brackets in fixtures adjustable for different sizes; multiple fixture for milling ends of bearing caps.

MOTOR BUSES

Gasoline-Electric. Electric Drive Bus Engines Have Unique Operating Conditions, J. A. Queeney. Automotive Industries, vol. 60, no. 22, June 1, 1929, pp. 838–839, 3 figs. Some characteristics of gas-electric drive, and requirements made of engines for use with such drives is brought out in experimental laboratories of Philadelphia Rapid Transit Co.; power of Knight-type power plant has been increased from 60 to 94 hp. by design changes and additions; compression ratio increased; two-spark ignition systemized; manifold system redesigned; Godward gas generator adopted.

MOTOR TRUCKS

Brakes. Brake Efficiency, R. G. Tolley. Motor Transport (Lond.), vol. 49, no. 1268, July 1, 1929, p. 7. Discussion of how motor-truck brakes may be impaired by faulty design and adjustment; brake linings; distribution of braking efforts.

Stewart-Warner Brake Uses Momentum. Commercial Car Jl., vol. 37, no. 5, July 1929, pp. 38–39 and 54. Design and operation of 4-wheel braking system comprising two shoe wedge adjustable brakes at wheels and two-shoe power amplifying unit built in rear of transmission; unit obtains power from drum mounted on transmission shaft.

Tank—Gasoline Transportation. Recommended Good Practice for the Construction and Operation of Automobile Gasoline Tank Trucks. Nat. Fire Protection Assn.—Proc. of mtg. May 13–16, 1929, pp. 433–438, 3 figs. Recommendations of Committee on Flammable Liquids covering requirements for fire prevention.

Winch Gear. Extending the Use of Motor-Vehicles Beyond the Transportation Field, T. C. Smith. Soc. Automotive Engrs.—Jl., vol. 25, no. 1, July 1929, pp. 55–60, 10 figs. Various uses that have extended field of profitable operation of motor vehicles beyond that of transportation are described as examples of recent development which is gaining momentum; deficiencies of lay-shaft take-off and take-off opening; pulling overhead and underground cable; setting poles with winch and derrick; loading and transporting heavy equipment; winch rope winder with automatic brake; power earth-boring machines.

N

NATURAL-GAS PIPE LINES

Corrosion. The Status of the Investigation of Pipe Line Protection Against Corrosion. Am. Gas Assn. Monthly, vol. 11, no. 8, Aug. 1929, pp. 489–493, 1 fig. Tests of protective coatings for pipe lines are to be made by American Gas Assn. in cooperation with Bur. of Standards, as pointed out.

NITRIDATION

Wear Resistance. Obtaining Wear Resistance by Nitriding, J. B. Nealy. Machy. (N. Y.), vol. 35, no. 10, June 1929, pp. 727–729, 1 fig. Discussion of how nitralloy steels are heat-treated to improve physical properties and nitrided to obtain superior wearing surface; analyses and tests of steels adapted for nitriding process comparative hardness of carburized and nitride steels; preparation of work for treatment; auxiliary equipment employed; control of gas flow and furnace temperature.

NON-FERROUS METALS

Fatigue. Fatigue Studies of Non-Ferrous Sheet Metals, J. R. Townsend and C. H. Greenall. Bell System Technical Jl., vol. 8, no. 3, July 1929, pp. 576–590, 12 figs. Previously indexed from Am. Soc. Testing Materials—advance paper, for mtg. June 24–28, 1929.

O

OIL BURNERS

Fuel Atomization. Mechanical Atomization a Marine Development, D. J. Irish. Fuel Oil, vol. 8, no. 2, Aug. 1, 1929, pp. 19–20, 122–125 and 127, 1 fig. Mechanical atomization of fuel oil is incorporated as basic principle in design of many domestic oil burners; each particle of oil leaving orifice has been subjected to three forces: horizontal pump force; centrifugal force of rotation and force of gravity; air most satisfactorily admitted into combustion chamber by air register; advantages of mechanical atomization.

OIL ENGINES

United States. Oil Engine Production in the United States, Oil Engine Power, vol. 7, no. 8, Aug. 1929, pp. 442–443, 1 fig. Rise of oil engines has been from zero horsepower in 1890 to 6,000,000 horsepower in 1930; curves showing growth of oil engines; confusion in oil engine nomenclature.

OIL WELLS

Pumping. For More Efficient Pumping, R. R. Robinson. Oil Bul., vol. 15, no. 8, Aug. 1929, pp. 819–821 and 885, 6 figs. How ingenious new device helps to synchronize elements necessary for correct lifting of oil.

P

PAPER MACHINERY

Roll Winders. Multiple Motor Winder Drive, S. A. Staege. Paper Industry, vol. 11, no. 4, July 1929, pp. 661–662, 1 fig. Studies and investigations of winding paper rolls have disclosed importance of maintenance of correct relative torques delivered to several winder drums; braking generator and tension regulator.

PETROLEUM PIPE LINES

Electric Pumping. Economics of Electric Pipe-Line Pumping, J. B. Thomas. Petroleum (A.S.M.E. Trans.), vol. 51, no. 14, May-Aug. 1929, pp. 69–74 and (discussion) 74–75, 6 figs. Paper reviews "state of art" in both oil pipe-line and electric-power supply industries as affected by use of electric power for pipe line pumping; indicates general construction and operating costs of pipe-line pumping stations and certain economic factors affecting cost of pumping oil; method of analysis including these factors is outlined and detailed solution of typical problem given.

PISTON RINGS

Cork-Sealed. Cork-Sealed Piston Ring. Engineering (Lond.), vol. 128, no. 3312, July 5, 1929, p. 30, 1 fig. Cork-Sealed Piston Ring Co. of Denver has designed and placed on American

market ring which is fitted with soft fibrous backing; this backing, in form of gasket, is made from powdered cork; in process of manufacture, gasket is subjected to great pressure to consolidate material, and is treated with chemicals to make it heat resisting.

PLANERS

Metal Working. Heavy Planing and Milling Machine. Machy. (Lond.), vol. 34, no. 872, June 27, 1929, pp. 407–408, 1 fig. Description of planing and milling machines for heavy duty developed by Schiess-Defries, Desseldorf; by using correctly toothed gears of high-grade material planers can be run at relatively high speeds, excessive speeds being avoided, since it is almost impossible to clamp heavy work pieces of considerable height so rigidly that they do not move under cut; details of combination planing and milling machine; width between uprights 13 ft. 6⅞ in.; maximum height below milling heads 11 ft. 10⅛ in.

PLASTICS

Pyroxylin. Pyroxylin as an Imitative Material, J. Rossman. Plastics, vol. 5, no. 8, Aug. 1929, pp. 442 and 459–461. Further review of patent literature brings out that one of most interesting applications of pyroxylin plastic materials has been production of artificial pearl and sea-shell effects.

POLISHING

Bores. The Surface Finish of Holes, O. Schliffe. Engineering (Lond.), vol. 128, no. 3313, July 12, 1929, pp. 33–35, 6 figs. Account of author's experiments on holes; these are generally made by twist drills and finished by reaming; for securing higher degree of accuracy and polish, internal grinding machines are used; one way of increasing accuracy of bore and smoothness of surface in holes is by press-finish method; hole, after drilling and reaming, is brought to size and finish by forcing through it hard and high-polished steel ball; depth of grooves left is too small for measurement by any ordinary form of internal micrometer, and resort was had to gelatine casts, as described by Thomas.

POWER PLANTS

Peak Loads. Handling the Peak-Load Problems, A. G. Christie. Power, vol. 70, no. 5, July 30, 1929, pp. 179–182, 3 figs. Methods of carrying peak loads are discussed and their adaptability analyzed; steam storage offers large savings when local conditions are favorable.

PRESSES

Friction Drive. Advances in Friction Press Design, O. Georg. Eng. Progress (Berlin), vol. 10, no. 8, Aug. 1929, pp. 207–209, 5 figs. Results of tests carried out by Maschinenfabrik Hasenclever A.-G., Duesseldorf, have been design of new heavy-duty press; chief features are improved drive with offset friction disks, and servomotor for pressing disks into contact under simultaneous regulation of contact pressure; press is built for maximum capacity of 3000 tons while normal operating capacity is rated at 1600 tons.

R

REFRACTORY MATERIALS

Testing. The Dissociation of Carbon Monoxide in Contact With Refractory Materials, D. W. Hubbard and W. J. Rees. Ceramic Soc.—Trans. (Lond.), vol. 28, no. 6, June 1929, pp. 277–309, 19 figs. Research described was carried out in order to investigate further dissociation of carbon monoxide under influence of catalysts, and in particular of refractory materials; this has important bearing on question of disintegration of blast-furnace linings; some specimens of corroded bricks from upper part of blast furnace, where temperature is not above 500 to 600 deg., were examined: attempts were made to discover probable causes of this carbon deposition assumed to be result of dissociation of carbon monoxide.

REFRIGERATING COMPRESSORS

Membrane. The Membrane Compressor. Ice and Cold Storage (Lond.), vol. 32, no. 377, Aug. 1929, pp. 195–196, 5 figs. Simple and robust machine of French manufacture on unorthodox lines; principle explained and illustrated; construction and operation; installations of compressor.

REFRIGERATORS

Welding. Welding in Domestic Refrigeration, F. E. Sellman. Acetylene Jl., vol. 31, no. 2, Aug. 1929, pp. 75–77, 2 figs. Oxyacetylene welding is used throughout in 74 welds required to manufacture refrigerator; welding operations are described.

ROCKET PROPULSION

Thermodynamics of. Thermodynamics of Rockets (Zur Thermodynamik des Raketenantriebes), K. Baetz. Maschinen-Konstrukteur (Leipzig), vol. 62, no. 3, Feb. 1, 1929, pp. 50–57, Theoretical mathematical analysis proving possibility of traveling in space.

S

SCREW THREADS

Manufacture. Mechanical Handling of Screw-Machine Parts, G. S. Brady. Am. Mach., vol. 71, no. 4, July 25, 1929, pp. 175–178, 7 figs. Description of screw-machine department of Schenectady plant of General Electric Co.; all automatics and heavy-turret lathes assembled in large building and arranged to save time and space; automatics are set up in form of horseshoe, open end of shoe facing into center aisle, and all stock feeds of machines are from center; roller conveyor passes completely around machine room, and has elevator station in center of each horseshoe; overhead monorail removes buckets of work and chips.

SEAPLANE CATAPULTS

Heinkel K-2. The Heinkel Catapult on the S. S. "Bremen." Aviation, vol. 2, no. 5, Aug. 3, 1929, pp. 263–264, 3 figs. Description of Heinkel K-2 catapult installed on North German Lloyd liner Bremen; catapult is installed on turntable amidship between funnels and consists also of railbearer or runway, skid or car, and compressed-air accelerating and testing devices; comparison with U. S. Navy and Chantiers Ile-de-France catapults.

SEAPLANE HULLS

Design. The Hydrodynamical Efficiency of Flying-Boat Hulls and Seaplane Floats, J. H. Lower. Flight (Lond.), vol. 21, no. 26, June 27, 1929 (Aircraft Engr. Supp.), pp. 49–50, 2 figs. Formulas are given for comparing efficiency of various models of flying-boat hulls and seaplane floats when carrying out tank tests; flying-boat hulls are more efficient than twin seaplane floats for major portions of speed range during take-off run.

SHELLS

Blanking. The Determination of Blanks for Rectangular Shells, J. Langton. Machy. (Lond.), vol. 34, no. 876, July 25, 1929, pp. 527–528, 3 figs. Method of determining blank for rectangular shell is described; obtaining sides of blank where pure bending occurs; approximate idea of increase of length and width of blank obtained by comparing length of arc of top of shell with straight line with top flat and increasing blank dimensions accordingly.

SNOW REMOVAL

Airports. Snow Removal on Airports. Pub. Works, vol. 60, no. 8, Aug. 1929, pp. 292–293, 3 figs. Snow-plow clearing of runways at Cedar Rapids, Iowa; runways cleared by "Caterpillar" 60 on La Plant-Choate hydraulic operated "V" type plow.

SPRINGS

Design. New Type of Spring (Sur un type nouveau de ressort), D. Wolkowitsch. Académie des Sciences—Comptes Rendus (Paris), vol. 188, no. 19, May 6, 1929, pp. 1228–1230; see also Génie Civil (Paris), vol. 94, no. 20, May 18, 1929, pp. 483–484. Principles of design of spring in which displacement of sections of one with reference to other is of sliding nature according to use of word in theory of elasticity.

Helical. Time of Oscillation in Helical Springs, J. W. Rockefeller, Jr. Machy. (N. Y.), vol. 35, no. 10, June 1929, pp. 748–751, 2 figs. Charts for determining period of vibration and damping factor in design of helical springs are given and discussed.

SPROCKETS

Measurement. Measurement of Chain-Wheel Teeth. Machy. (Lond.), vol. 34, no. 876, July 25, 1929, pp. 525–526, 2 figs. Information is given regarding application of disk or roller method of checking spur gears, to determine amount of error existing in thickness of teeth of chain wheels.

STEAM

High Pressure. Higher Steam Pressures and Temperatures. Nat. Elec. Light Assn.—Serial Report, no. 289–73, June 1929, 35 pp., 39 figs. Report is subdivided into sections; recent installations; operating companies statements including design details; performance and operating experience from 600 to 1400 lb.; review of papers, as follows; properties of metals at elevated temperatures, A. E. White and C. L. Clarke; relation of embrittlement to higher steam pressures and temperatures, F. G. Straub; higher pressures and temperatures, C. F. Hirshfeld; relative construction costs of high- and low-pressure installation; manufacturers statements.

STEAM CONDENSERS

Surface. Contemporary Practice in Condenser Surface Dimensions. Power Engr. (Lond.), vol. 24, no. 281, Aug. 1929, pp. 306–307 and 337, 2 figs. Comparison between design data and actual performance figures.

Resistance to Flow of Cooling Water in Surface Condensers, T. Petty. Mech. World (Lond.), vol. 86, nos. 2219 and 2220, July 12, and 16, 1929, pp. 27–28 and 51–54, 5 figs. July 12: Resistance offered by condenser itself from inlet to outlet flange is discussed; resistance in water-boxes; resistance at entrance to tubes; resistance to flow offered by tubes themselves July 16: Rational formulas for pipe resistance are given for determining resistance of condenser tubes; formulas are capable of useful application in dealing with general circulating water pipe system.

STEAM-ELECTRIC POWER PLANTS

Auxiliaries. Heat Balance and Station Auxiliaries. Elec. West, vol. 62, no. 6, May 15, 1929, pp. 442–448, 13 figs. Report of Heat Balance and Station Auxiliary Committee of Pacific Coast Electrical Assn., including proposed installations with flow-diagram study for 1200-lb. station; representative feedwater heater installations on Pacific Coast with flow diagram; operating and starting characteristic of auxiliary steam-driven house-generator sets for emergency use; evaporator equipment; continuous blow-down, and double-distillation system; turbine spindle turning device in use at Seal Beach station for quick starting of large turbo-generator units.

England. Peterborough's New Pulverized Fuel Power Station. Elec. Times (Lond.), vol. 75, no. 1966, June 27, 1929, pp. 1039–1043, 9 figs. Plant contains turbo-alternator units of ultimate capacity of 48,500 kw. in old and newly installed equipment; diagram showing arrangement of plant from coal drier to station busbars; coal-drying plant of 12–15 tons per hr.; pulverizing mill with output of 12 tons per hr.; primary air fans and coal feeder; Spearing boilers and condensers; high- and low-pressure, twin-cylinder, turbo-alternator set, 12,500 kw.; system is designed for 90,000 lb. of steam per hr. at 260 lb. per sq. in. and 700 to 750 deg. fahr.; operates at 6600/400 volts.

Peak Loads. The Peak-Load Problems in Steam Power Stations, A. G. Christie. Fuels and Steam Power (A.S.M.E. Trans.), vol. 51, no. 12, May-Aug. 1929, pp. 109–117 and (discussion), 117–124, 16 figs. Use of load-duration curve for purpose of studying annual peak loads is analyzed and conclusions are drawn that plant intended for annual-peak-load service should only be installed at lowest possible first cost, and that economy of peak-load equipment can be sacrificed to secure low initial cost; three plans that appear most promising are those involving use of steam accumulators, of peak-load units, and of present plant after new base-load equipment has been added; possible annual savings through application is exemplified.

STEAM PIPE LINES

High-Pressure. High Pressure Steam Piping of the New Power Plant at Issy-les-Moulinaux (Les tuyauteries de vapeur à haute pression de la nouvelle centrale d'Issy-les-Moulineaux). Génie Civil (Paris), vol. 95, no. 3, July 20, 1929, pp. 66–67. Analysis of paper presented by Dessus, Leconte and Galibourg at conference of Société des Ingenieurs Civils regarding production and utilization of large quantities of steam at 450 deg. and 44 kg. per sq. cm.; preliminary study, metals, manufacture, specifications for acceptance tests.

STEAM POWER PLANTS

High-Pressure. Hundred Atmospheres Equipment of Superpower Plant in Mannheim (Die 100 at-Anlage des Grosskraftwerkes Mannheim), F. Marguerre. V.D.I. Zeit. (Berlin), vol. 73, nos. 26 and 28, June 29 and July 13, 1929, pp. 913–920 and 993–998, 33 figs. June: Selection of steam pressure and firing equipment; general layout of plant and details; design of boilers. July: Fittings and packings, feed pumps, turbines, automatic control system.

Power and Process. Balancing Heat and Power in Industrial Plants, R. V. Kleinschmidt.

Fuels and Steam Power (A.S.M.E. Trans.), vol. 51, no. 12, May-Aug. 1929, pp. 145–150 and (discussion), 150–157, 7 figs. Paper indicates importance of various factors in increasing amounts of by-product power that can be generated in industrial plants using process heat; curves are presented which give results of detailed analysis of problem of water heating; importance of adequate study of heat and power requirements of process and of possible improvements or alterations of process as basis for improvement of heat-power balance is emphasized.

STEAMSHIPS

Pulverized-Coal-Fired (West Alsek). Unit System of Pulverized Fuel in Ships. Engineering (Lond.), vol. 128, no. 3314, July 19, 1929, p. 87, 1 fig. Account of installation at sea on unit system of firing, namely, that having independent mills, and experiments that preceded it, which were, no doubt, those referred to; equipment, which has been installed in West Alsek, embodies Todd Unit System of pulverized-coal burning, and has been fitted by Todd Shipyards Corp.

Turbine. New L. N. E. R. Cross-Channel Steamers. Ry. Gaz. (Lond.), vol. 51, no. 2, July 12, 1929, pp. 58–59 and 86, 5 figs. Descriptive notes on three new vessels, each with gross tonnage of 4300 tons, for Harwich-Hook night service; they are largest cross-channel steamers sailing from England; propelling machinery consists of Brown-Curtis Compound turbines, driving twin screws through single-reduction gearing.

STEAM TURBINES

Design. Condition Curves and Reheat Factors for Steam Turbines, C. C. Franck. Fuels and Steam Power (A.S.M.E. Trans.), vol. 51, no. 12, May-Aug. 1929, pp. 125–132, 10 figs. Theory for condition curves and reheat factors developed by study of basic thermodynamic principles involved; method is developed which makes possible construction of condition curves for any turbine, when certain operating or guarantee characteristics are known; theory has been applied to determine values for reheat factors.

STEEL

Automobile. A Comparison of Auto Steels, J. W. Urquhart. Blast Furnace and Steel Plant, vol. 17, no. 8, Aug. 1929, pp. 1161–1164 and 1171, 1 fig. Discussion of various steels used in automobile manufacture; compositions of various steel alloys and their appropriateness for chassis engine and body parts.

Elastic Limit. Martin Elastic Limit Steel, P. G. Rouse. Engineer (Lond.), vol. 148, no. 3836, July 19, 1929, p. 71, 2 figs. Discussion of microstructure and manufacture of Martinel steel which is special quality steel subjected after rolling to special heat treatment which ensures formation of microstructure most favorable to greatest elastic strength of steel; reference made to paper by F. G. Martin describing development of steel; use of Martinel steel for parts of Empress of Britain.

Heat Treatment. A Study of Burning and Overheating of Steel, W. E. Jominy. Am. Soc. for Steel Treating—Trans., vol. 16, no. 2, Aug. 1929, pp. 298–313, 8 figs. Effect of oxidizing and reducing atmosphere on steels heated for forging were studied and results given. (To be continued.)

Rimmed. The Physical Chemistry of Rimmed Steel, J. E. Carlin. Am. Soc. for Steel Treating—Trans., vol. 16, no. 2, Aug. 1929, pp. 293–297. First part of article deals briefly with early method of manufacture of low-carbon steels by basic open-hearth process, and start and development of rimming process; second part explains rimmed steel from physical chemistry standpoint.

Research. The Application of Science to the Steel Industry, W. H. Hatfield. Am. Soc. for Steel Treating—Trans., vol. 16, no. 2, Aug. 1929, pp. 278–292, 18 figs. This section covers carbon and high-speed tool steels; accompanied by photomicrographs of each in variously treated conditions; results are described of an investigation of table knives, razors, etc., to determine characters of those possessing good cutting edges as compared to those with poor cutting edges; some operations to be observed in manufacture of cutlery are discussed. Sixth section of third Edward De Mille Campbell Memorial Lecture.

STOKERS

Chain-Grate. Recent Developments in the Use of Chain-Grate Stokers (Neuzeitliche Entwicklung und Belastung von Wanderrosten), Pradel. Papier-Fabrikant (Berlin), vol. 27, no. 1, Jan. 6, 1929, pp. 8–13, 6 figs. Author considers this type of boiler firing superior to use of powdered coal; notes on proper plant construction and operation are given.

STRIP MILLS

Continuous. Continuous Hot Strip Mill at Sharon. Blast Furnace and Steel Plant, vol. 17, no. 8, Aug. 1929, pp. 1168–1169, 5 figs. New mills of Sharon Steel Hoop Co., are designed to roll strips varying in size from 2½ in. by 0.028 in. by 0.065 in. from 30-ft. billets at speed up to 2400 ft. per minute.

T

TESTING MACHINES

Fatigue. A New High-Speed Fatigue Testing Machine, H. S. Rowell. Engineering (Lond.), vol. 128, no. 3315, July 26, 1929, pp. 97–98, 6 figs. Features of machine designed for endurance testing of such plates as are used in laminated springs, also for general endurance bend test.

TRANSPORTATION

Future of. What Next in Transportation. R. V. Wright. Pacific Ry. Club—Proc., vol. 13, no. 3, June 1929, pp. 8–11, 13–16 and 19. Address opened by citing peculiar accident; kaleidoscopic changes; passenger traffic on railroads has decreased because of private automobile, motor bus and airplane; necessity for research work; suggests one transportation system to combine all types of travel which will best meet needs of country. Read before Pacific Ry. Club.

TUNGSTEN-CARBIDE CUTTING TOOLS

Germany. German Practice With Tungsten-Carbide Tools, G. Schlesinger. Am. Mach., vol. 71, no. 2, July 11, 1929, pp. 37–42, 12 figs. Review of German experience over period of several years with super-head cutting tools, and also some laboratory tests on their life; discussion of inherent qualities of tungsten carbides, tool shapes, and grinding and cutting speeds; effect on machine design centers chiefly in provision of better bearings; recommended cutting angles.

Grinding. Fine and Soft Wheels Recommended for Grinding Tungsten Carbide Tools, S. M. Hershey. Abrasive Industry, vol. 10, no. 8, Aug. 1929, p. 19, 1 fig. Detailed methods that have proved satisfactory in laboratories of Abrasive Co. in tool grinding.

The Grinding of Tungsten-Carbide Tools, A. H. Prey. Machy. (Lond.), vol. 34, no. 877, Aug. 1, 1929, p. 571. Precautions in grinding tungsten-carbide tools are pointed out and grades of material are given for rough grinding, finish grinding and honing.

Grinding of Tungsten Carbide Requires Care. Iron Trade Rev., vol. 85, no. 3, July 18, 1929, p. 137, 1 fig. Data pertaining to grinding of tungsten-carbide tools supplied by Thomas Prosser and Son, New York.

Testing. A User Tests Tungsten-Carbide Tools, F. S. Walters. Machy. (N. Y.), vol. 35, no. 12, Aug. 1929, pp. 934–935. Results of actual shop tests conducted to determine suitability of tungsten carbide for machining various materials; best results on rigid well-lubricated machines; special wheels required for grinding tungsten-carbide tools; higher production and reduce sharpening in machining brass and bronze; tool stands up well under intermittent cuts on cast iron at high speed; marked lasting qualities; cutting speed quadrupled on bakelite and materials of similar composition; resistance to abrasive action of marble.

W

WATER SOFTENING

Zeolite Process. Municipal Zeolite Water Softening, H. N. Jenks. Can. Engr. (Toronto), vol. 56, no. 24, June 11, 1929, pp. 593–596, 3 figs. Results of preliminary studies made on practical-scale softening apparatus in sanitary engineering laboratory of Iowa State College; restrictions in use of zeolite; program of investigation relating to engineering aspects of municipal zeolite water softening; water-softening capacity studies; regeneration and wash-water studies; under-drain distribution system. Paper presented before Am. Water Works Assn.

WEIRS

Measurements. Measurements of Fluid Flow With Triangular Notches. Power Engr. (Lond.), vol. 24, no. 281, Aug. 1929, pp. 313–315, 3 figs. Available data reviewed and method of calculation suggested by B. M. Thornton, effects of notch edges; dimensional analysis of flow.

WHEELS

Steel—Manufacture. Steel Wheels for Agricultural and Road Building Machinery, S. J. Montgomery. Can. Mach. (Toronto), vol. 40, no. 10, May 16, 1929, pp. 33–35, 7 figs. Description of methods of manufacturing steel wheels employed in Ontario plant; welding is done electrically under 200 kw. Federal semi-automatic welder; casting of hub in both dry-sand and cast-iron molds described.

WIRE

Specifications. Standard Specifications Are Drafted for Wires and Cables. Wire, vol. 4, no. 8, Aug. 1929, pp. 265–266 and 281–282. Suggested standardized specifications proposed by Committee on wires and cables of American Standards Assn. treats in detail covering, size of conductor, and saturating compound for weather-proof wires; drip, bending, and melting tests of saturated cable are explained.

WIRE ROPE

Lubrication. The Selection and Application of Wire Rope Lubricant, C. D. Meals. Wire, vol. 4, no. 7, July 1929, pp. 230–231 and 246–248, 1 fig. See also Iron and Steel of Canada (Gardenvale, Que.), vol. 12, no. 7, July 1929, pp. 183–184 and 196, 1 fig. Recommendations for materials and methods to retard corrosion, reduce friction and insure longer life in service.

WOOD

Drying. Drying of Wood (Ueber die Holztrocknung), R. Mueller. Maschinenbau (Berlin), vol. 8, no. 12, June 20, 1929, pp. 398–403, 10 figs. Report from testing laboratory of Siemens and Halske A. G. on results of two series of experiments using oak, alder, walnut, red beech, and pine; special method for determining relationship between changes in volume and moisture content of woods; data on absolute moisture content of well seasoned woods.

Finishing. Wood Finishing, M. C. Roberts. Indus. Finishing, vol. 5, no. 9, July 1929, pp. 56–64 and 99–103, 1 fig. Description, starting with wood surface in white and continuing through staining, filling, drying, and rubber operations, with supplementary explanations about choice, preparation, application and drying of each type of materials.

WOODWORKING MACHINERY

Automatic. Automatic Production of Small Wood Parts, I. B. Whinery and G. A. Whinery. Wood Industries (A.S.M.E. Trans.), Sept.-Dec. 1928, pp. 17–20, and (discussion) 20–21, 5 figs. Author describes three examples of automatic woodworking machines: (1) knob-tapping machine, chosen to show how production may be increased by performing single operation more rapidly than best operator could do it by hand; (2) square-knob blanking machine, to illustrate combination of several distinct operations in one mechanism; (3) rosette machine, as example of one, the primary purpose of which is to achieve quality without sacrificing speed; economic principles involved in use of automatic woodworking machinery are discussed.

Ball Bearings. Ball Bearings as Applied to Woodworking Machinery, H. E. Brunner. Wood Industries (A.S.M.E. Trans.), vol. 51, no. 5, Jan.-Apr. 1929, pp. 13–23, 14 figs. Anti-friction bearings have come into general use in all classes of woodworking machinery; their adoption has been largely influenced by trend to higher operating speeds and increased production; principles underlying practice generally followed are brought out by descriptions of actual bearing installations; question of lubrication is considered, and requirements of lubrication peculiar to anti-friction bearings are discussed in detail.

Lubrication. Lubrication of Ball-Bearing Woodworking Spindles, H. R. Reynolds. Wood Industries (A.S.M.E. Trans.), vol. 51, no. 5, Jan.-Apr. 1929, pp. 29–31 and (discussion) 31–32, 8 figs. Methods of lubrication especially suitable for speeds of 4000 to 7500 r.p.m. which is about range of woodworking spindles; where oil is used its level should not be over center of lowest ball if speeds are higher than 500 r.p.m.; at 5000 r.p.m. very light spindle oil should be used; if grease of proper consistency is used, housing can be filled.

WROUGHT IRON

Manufacture. A New Development in Wrought-Iron Manufacture, J. Aston. Am. Inst. of Min. and Met. Engrs.—Tech. Pub., no. 228 for mtg. Sept. 1929, 12 pp., 4 figs. Supplement to paper indexed in Eng. Index, 1926, p. 806, from Am. Inst. Min. and Met. Engrs.—Trans., no. 1595-C; account of two years experience in commercial operation of plant using process earlier described; discussion of details of operation, which correspond to and parallel major subdivisions of hand puddling method; refining is done in small converters.

IN TWO SECTIONS—SECTION TWO

MECHANICAL ENGINEERING

Published by The American Society of Mechanical Engineers, 29 W. 39th St., New York, N. Y.

Volume 51 October, 1929, Section Two Number 10

What It's All About

THROUGH education the gains of civilization are made secure. Cultural, social, and economic advances become the heritage of greater and greater numbers of people as generation after generation organizes its knowledge and uses it intelligently. The secret of the progress made by democratic institutions during the past century lies not so much in the desire of peoples to be free as it does in the possibility of their participation in the benefits of independence. What distinguishes our age from golden ages of the past is the fact that machine civilization has so increased our wealth and productivity that the great mass of humanity which formerly lived as slaves has today the hope of an economic emancipation. The use of power and the application of engineering principles to the problems of life have been potent factors in assisting social and economic progress.

MECHANICAL ENGINEERING is essentially an instrument of education. Every month its pages are filled with articles which serve to broaden and educate its readers. Written for technical men, these articles are none the less interesting to the intelligent layman. This single-sheet summary of the contents of the October issue is an attempt to tell in non-technical language "what it's all about."

A School for Teachers

THIS summer at Purdue University—which has the largest enrolment of undergraduate students in engineering—the Society for the Promotion of Engineering Education conducted a school for mechanical-engineering teachers. Deans, professors, and instructors came from practically every state of the Union. Morning, afternoon, and evening they listened to lectures and discussed the problems which face those who must impart technical knowledge to men of college caliber. While many of the lectures dealt with curriculum content and teaching technique, others dealt with broad phases of the subject-matter. Some of these lectures are published in the October issue of MECHANICAL ENGINEERING, and will be found quite as valuable to the practicing engineer and the general reader as they were to those for whom they were written.

Trends in Power-Plant Development

SINCE the war there have been few instances of prices that have not advanced. However, in spite of the fact that electric-power companies have been faced with rising costs of coal and other items of expense, they have been able to increase the efficiency of operation and distribution so successfully that the price of electricity is no higher than it was before the war. This noteworthy accomplishment is a source of justifiable pride to engineers.

In a lecture delivered at Purdue and published in the October issue of MECHANICAL ENGINEERING, C. F. Hirshfeld, chief of the research department of the Detroit Edison Company, reviews the trends in power-plant development in the United States and Europe. The most noteworthy advances of the past twenty years have been in connection with the increase in steam pressures and temperatures. Aside from the increase in temperatures and pressures, there have been gains in economy of operation, in size of steam-generating and turbine units, in technique of operation, and in knowledge of the behavior of materials under the severe conditions of modern operation.

Materials in Machine Construction

IN A LECTURE delivered at Purdue, and published in the October issue of MECHANICAL ENGINEERING, Prof. H. F. Moore of the University of Illinois defines with much care certain concepts essential to the study of "Materials in Machine Construction."

Of great interest is the section of the lecture devoted to "fatigue" strength under repeated loading. Professor Moore's researches in this field have placed him in a position of authority with respect to this property of materials. Written from the point of view of the designer of machinery who must specify the materials in which his designs will be embodied, the lecture includes references to such important properties as hardness, ductility, toughness, and tenderness, and resistance to corrosion, important considerations in the choice of materials.

Materials Handling

IN THE United States, as Harold Vinton Coes points out in the Purdue lecture published in the October issue of MECHANICAL ENGINEERING, human labor is too expensive to be used in pushing, handling, and otherwise manually moving materials. "Restrictive immigration," he says, "has forced the consideration of practical ways and means of mechanizing the operations, particularly in materials handling, still performed by hand labor." This has made the development of materials-handling methods of great importance in this country. It is one of the major developments in American industry.

Industrial Management

ENGINEERING was originally confined to machines, materials, and methods; today it embraces also men and money. Hence engineering education, which is based on applied science, is being broadened to include the economic and social sciences, and among these is that very essential and practical subject of Industrial Management.

At Purdue, L. P. Alford, editor of "Management's Handbook," lectured on "The Fundamentals of Management Applied to Industrial Enterprises." The recipient

of the Melville Award of the A.S.M.E. because of his paper on "The Laws of Management," Mr. Alford is one of the major prophets of management in this country. This fact lends especial force to his statements.

In his lecture, which is published in the October issue of MECHANICAL ENGINEERING, Mr. Alford makes it clear that the so-called laws of management are not like those of the more rigorous sciences, physics, chemistry, and mathematics, but are entirely statistical and experiential, as are those of the other social sciences. This fact has, of course, made it difficult to frame the laws and to get for them in engineering schools the same serious attention that the law of gravity has received.

Labor Relations

MR. SAM A. LEWISOHN, capitalist and mine owner, has given much study to the problem of labor relations. Representing the capitalist class and the executive, he addressed the school for mechanical-engineering teachers at Purdue on the subject of "Modern Labor Relations and the Engineer." His address is published in the October issue of MECHANICAL ENGINEERING.

Mr. Lewisohn's address is a plea for the inclusion of problems affecting labor in the curriculum of the student of engineering. He is quite definite in his opinion that this study should not be directed toward the training of routine and professional personnel and "welfare" officers, but should aim to develop the philosophy of this vexing problem so that the future executive heads of industry, as represented in the engineering undergraduate of today, shall be able to exercise an intelligent influence in the formation of labor policies.

Natural Flight

IT WAS Solomon who found "the way of an eagle in the air" too incomprehensible for him. Envying birds their mastery of the technique of flight, man has attempted to emulate them ever since the dawn of history, only recently to have become successful.

Maurice Boel, professor at the Charleroi University in Belgium, has investigated the problems of natural flight, chiefly as applying to birds.

In a paper read at a meeting of the Aeronautic Division of the A.S.M.E. in June of last year, Professor Boel reported his studies. The monograph is published in the October issue of MECHANICAL ENGINEERING.

Professor Boel did all manner of interesting things with pigeons and condors and albatrosses. In his present article he explains the theory which he has evolved by coordinating recent aerodynamical discoveries with early physiological studies. In seeking proof of his theory, he has traveled on three missions—to Senegal, to Argentine, and to the South Seas. "Today," he concludes, "man is doing nearly as well as the birds. In a little while he will be doing even better." What keen interest Solomon would have shown in Professor Boel's studies!

A Museum of Science and Industry

IN EUROPE—Paris, Munich, Vienna—and in London, the museum idea has grown to include science and industry, but in America only the beginnings of such institutions are to be found. To engineers, the educational value of a museum in which the public may learn something of the technological aspects of the civilization of which it is a part will appeal instantly.

In Chicago, Mr. Julius Rosenwald has given liberally for a museum of science and industry. It is in a formative stage, and its director, Waldemar Kaempffert, has an inspired vision of its character and function. He writes about his plans and ideas in the October issue of MECHANICAL ENGINEERING in an article entitled "A Dynamic Museum to Reveal Man's Technical Heritage." "In it," he says, "the people will have an opportunity to survey the technical and social progress of the past and to evaluate the status of the present." His determination to link technical and social advance will mark a distinctive contribution to the industrial-museum idea.

Hints to Householders

IT IS ONE of the prerogatives of the householder to operate his own heating plant. It is one of his social obligations to operate it in such a manner that it is not an offense to his neighbors. In parts of the country where soft coal is used as fuel, this is not easy to accomplish. Good intentions are no substitute for technical knowledge.

Mr. Victor J. Azbe of St. Louis, chairman of the A.S.M.E. Fuels Division, writes in the October issue of MECHANICAL ENGINEERING on "Smokeless Combustion in Domestic Heating Plants." If you operate a domestic heating plant you will find much valuable advice in Mr. Azbe's article.

Diesel Fuel Oil

THERE is a tri-party interest in Diesel fuel oil: that of the manufacturer of the Diesel engine, the refiner of the oil, and the operator who must run his engine on the oil he can buy in the market. It is natural, therefore, that these three interested parties should cooperate in a research program under the auspices of the A.S.M.E. The committee which has been at work on the subject for more than a year reported at a recent meeting of the A.S.M.E. Oil and Gas Power Division held in cooperation with the Pennsylvania State College. The progress report of this committee is published, with a résumé of the discussion it stimulated, in the October issue of MECHANICAL ENGINEERING.

Engineering Research in Germany

IT IS ONE of the functions of engineering societies to foster research. The great German society of engineers, the Verein Deutscher Ingenieure, has extensive interests in this field, and at a session of the Scientific Council, Dr. Conrad Matschoss, director of the V.D.I., reported on the researches instigated and promoted by that body. A translation of the report as printed in the *V.D.I. Nachrichten*, is published in the October issue of MECHANICAL ENGINEERING.

American engineers will be interested in the extent and variety of the researches mentioned in the report, and in the reference to the work of the A.S.M.E. in the flow of fluids.